

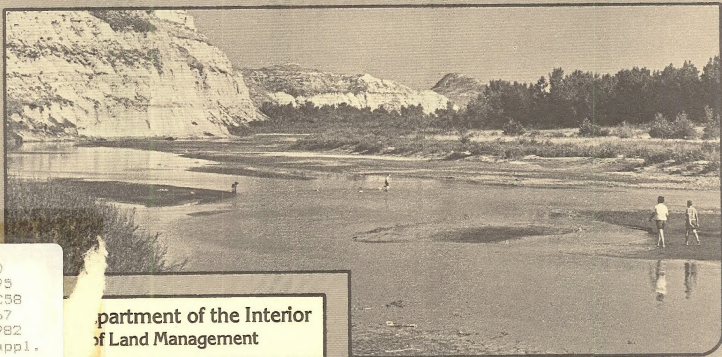


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# AIR QUALITY INFORMATION SUPPLEMENTAL TO THE FORT UNION COAL REGION DRAFT ENVIRONMENTAL IMPACT STATEMENT



September 1982



TD  
175  
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1982  
Suppl.

Department of the Interior  
Bureau of Land Management

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

3400 (932)  
Fort Union



# United States Department of the Interior

BUREAU OF LAND MANAGEMENT  
222 North 32nd Street  
P.O. Box 30157  
Billings, Montana 59107

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C58  
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Dear Reader:

The following is supplemental information to Chapters Two and Three of the Air Quality portion of the Fort Union Coal Region Draft Environmental Impact Statement.

Written comment on this additional air quality information from interested citizens, industry, and public agencies will be accepted after the October 8, 1982 cut-off date, extending to and including the Regional Coal Team meeting on October 19, 1982.

Readers should be aware that specific air quality information and issues will be addressed when any applications for resource development are filed with the proper permitting authorities.

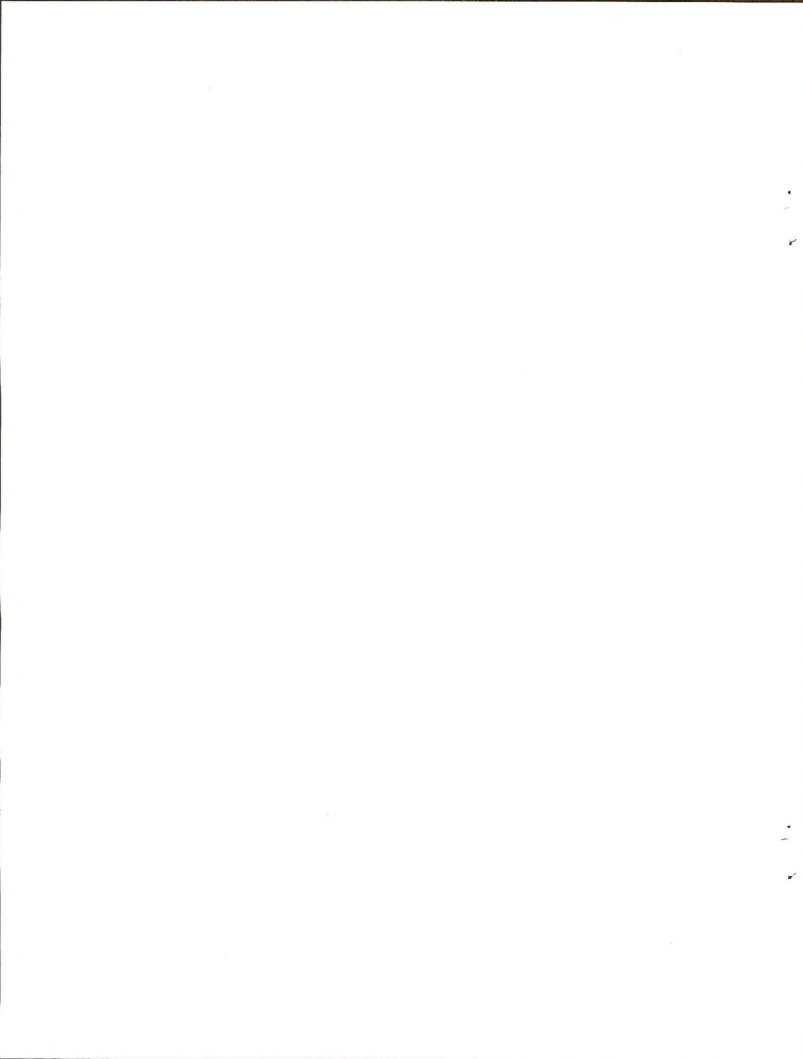
Comments should be sent to Mr. Lloyd Emmons, Acting Project Manager, Fort Union Project, Bureau of Land Management, 222 N. 32nd Street, P.O. Box 30157, Billings, Montana 59107.

Sincerely yours,

*Michael J. Penfold*

Michael J. Penfold  
State Director

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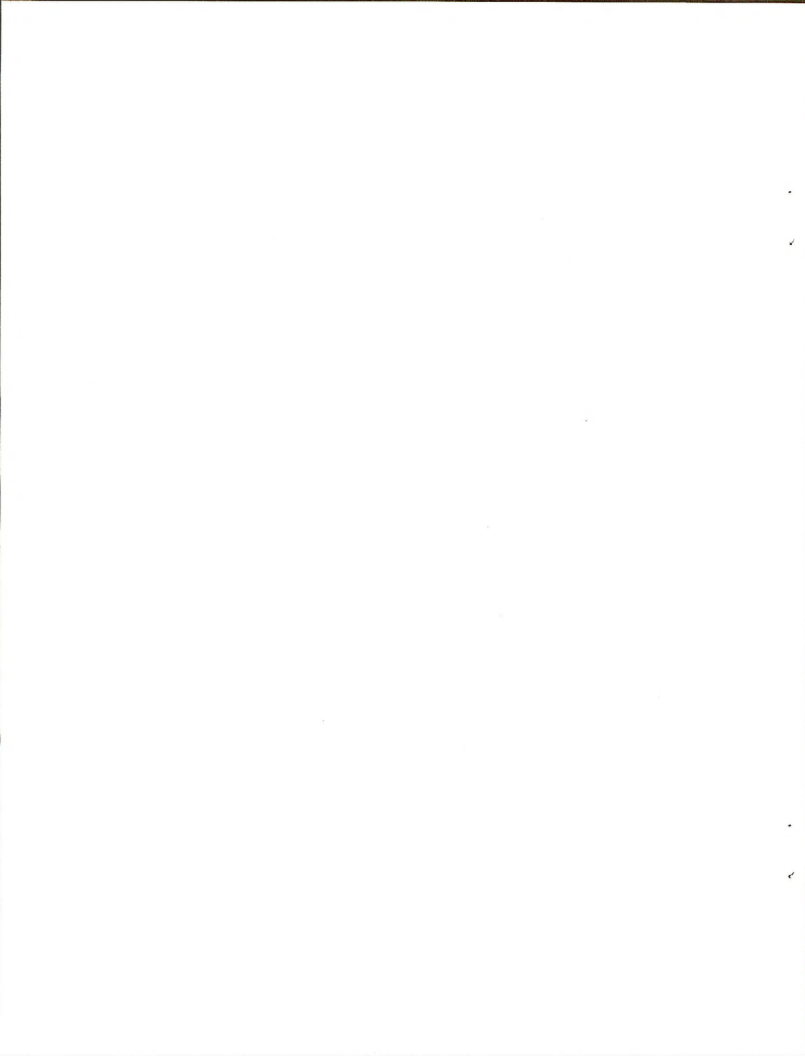
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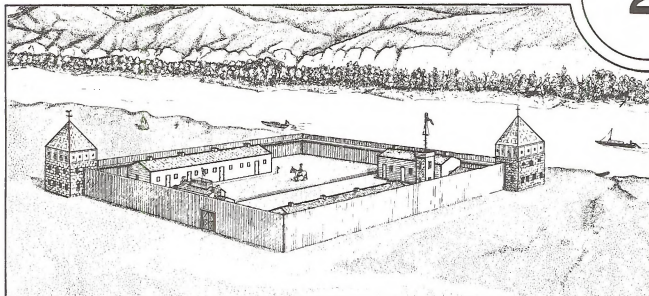
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## AFFECTED ENVIRONMENT

### AIR QUALITY AND CLIMATE

#### Climate and Meteorology

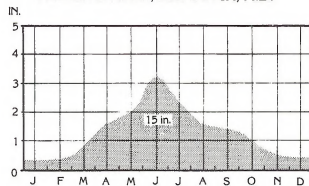
The Fort Union Coal Region of eastern Montana and western North Dakota is characterized by a semi-arid continental climate. Air masses which cross the region originate in the Arctic, the Gulf of Mexico, and the Northern Pacific. The Rocky Mountains, to the west of the region, modify the prevailing westerly flow of air masses from the Northern Pacific. There are no topographical barriers, however, to modify the flow of cold, dry air masses from the polar regions to the north and the warm, moist air masses from the tropical regions to the south. There are no distinct major air basins within the Fort Union region as a whole, and as a result there are often rapid changes in weather patterns over the Fort Union area.

The Fort Union area is a region of climatic extremes where temperatures vary widely on an annual, seasonal, and daily basis. Annual mean temperatures throughout

the region range from about 39°F in Minot to about 46°F in Miles City. The highest monthly mean temperatures occur in July (about 70° to 75°F), and the lowest monthly mean temperatures (about 8-15°F) are recorded in January.

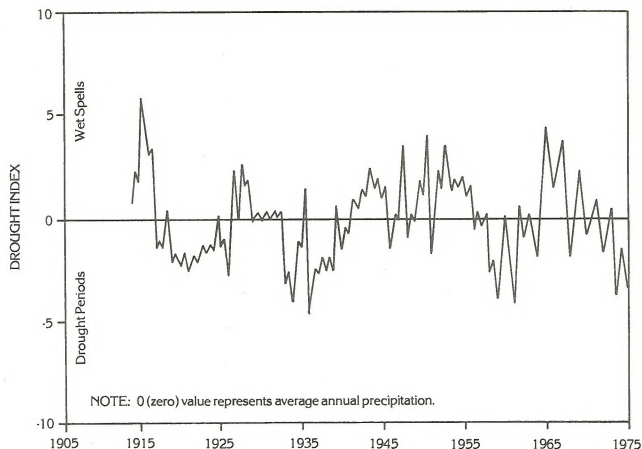
The Fort Union region receives, on the average, about 15 inches of precipitation per year, and most of this occurs in late spring or early summer (May-July) (see Figure 2-1). Snowfall averages about 33 inches per year. Annual averages can sometimes be misleading, however, and it is important to note that precipitation in the Fort Union region often fluctuates greatly from the annual mean (see Figure 2-2).

FIGURE 2-1 MONTHLY DISTRIBUTION OF PRECIPITATION, BISMARCK, N.D.



Source: Trewartha 1961.

FIGURE 2-2 RELATIVE OCCURRENCE OF DROUGHT AND WET SPELL PERIODS IN MANDAN FROM 1905 THROUGH 1975



Source: Ramirez et al., 1976

Prevailing winds in the Fort Union region are from the west-northwest, and average about 12 miles per hour throughout the region (see Figure 2-3). High gusting wind speeds are not uncommon in the region, particularly during the winter months.

Pollutant dispersion is also affected by atmospheric stability, a function of upper air temperatures and winds. The Fort Union region generally experiences frequent temperature inversions, which reduce mixing heights and tend to concentrate pollutants (see Table 2-1).

### Air Quality and Pollutants

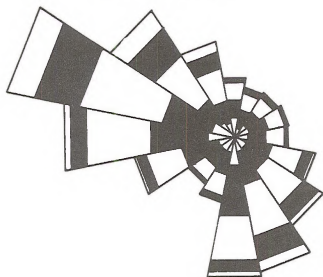
The pollutants which are of importance in the Fort Union region are total suspended particulates (TSP), sulfur dioxide ( $\text{SO}_2$ ), ozone ( $\text{O}_3$ ), nitrogen dioxide ( $\text{NO}_2$ ), hydrocarbons (HC), carbon monoxide (CO), hydrogen sulfide ( $\text{H}_2\text{S}$ ), lead (Pb), and various trace elements. Appendix A further identifies these important pollutants.

TABLE 2-1  
Representative Inversion Frequency and  
Mixing Height Data\*

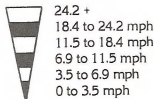
	Regional Values
Inversion Frequency (base 1500 ft.), %	
Annual	35
Seasonal Range	30-50
Mixing Height, ft.	
Mean Annual Morning	984-1312
Mean Annual Afternoon	4921-5249
Mean Annual Afternoon Range	1968-7874

\*Recorded at Bismarck, North Dakota

FIGURE 2-3 WIND ROSE FOR  
DICKINSON, N.D.



KEY



Wind Direction	%
N	3.6
NNW	5.9
NW	9.3
WNW	14.4
W	10.7
WSW	6.3
SW	3.5
SSW	4.2
S	8.8
SSE	8.6
SE	6.5
ESE	5.1
E	3.3
ENE	3.4
NE	3.2
NNE	3

Source: West-Central Regional EIS, 1978

An examination of the TSP data for 1979 and 1980 shows that, in rural areas of eastern Montana, the annual geometric mean concentrations range from 13 to 21 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ) at Scobey, and 20 to 27  $\mu\text{g}/\text{m}^3$  at Fort Peck and Lindsay. The figures represent up to 28% of the Primary National Ambient Air Quality Standard (NAAQS) at Scobey (Appendix C) and 35% of the Primary NAAQS and 45% of the Secondary NAAQS at Fort Peck and Lindsay. The highest 24-hour concentrations observed were 116  $\mu\text{g}/\text{m}^3$  at Scobey, 153  $\mu\text{g}/\text{m}^3$  at Fort Peck, and 208  $\mu\text{g}/\text{m}^3$  at Lindsay, and these represent up to 45%, 59%, and 72% respectively of the Secondary NAAQS. At the urban sites in Glendive and Miles City, Montana, the annual geometric means in 1980 were 18  $\mu\text{g}/\text{m}^3$  (24% of Primary and 30% of Secondary NAAQS) and 55  $\mu\text{g}/\text{m}^3$  (73% of Primary and 92% of Secondary NAAQS), respectively. The highest 24-hour concentrations observed at these sites were 68  $\mu\text{g}/\text{m}^3$  (26% of Primary and 45% of Secondary NAAQS) and 158  $\mu\text{g}/\text{m}^3$  (61% of Primary and 105% of Secondary NAAQS).

High volume sampler filters from Scobey were analyzed for sulfates ( $\text{SO}_4$ ) and nitrates ( $\text{NO}_3$ ) in 1979 and 1980. These analyses indicated mean annual concentrations of  $\text{SO}_4$  from 2.6 to 5.9  $\mu\text{g}/\text{m}^3$  and mean annual  $\text{NO}_3$  concentrations of 0.7 to 1.1  $\mu\text{g}/\text{m}^3$ . These values are consistent with what would be expected for background levels.

Rural sites in western North Dakota showed annual geometric means of 11 to 28  $\mu\text{g}/\text{m}^3$  TSP, and peak 24-hour TSP concentrations generally in the range of 90  $\mu\text{g}/\text{m}^3$  to 290  $\mu\text{g}/\text{m}^3$ . In urban areas in North Dakota, annual geometric means were generally from 18 to 29  $\mu\text{g}/\text{m}^3$  TSP. The rural sites reach as high as 47% of the more stringent Secondary NAAQS for the annual geometric mean and as high as 193% of the 24-hour Secondary NAAQS. On the other hand, the urban areas are as high as 48% of the Secondary NAAQS.

Except near sources, sulfur dioxide concentrations in the region are very near zero. The  $\text{SO}_2$  monitoring conducted near Scobey, Montana, for example, indicates an annual average of 3  $\mu\text{g}/\text{m}^3$  (4% of the Primary NAAQS) with an hourly maximum concentration of 43  $\mu\text{g}/\text{m}^3$  (3% of the Montana Ambient Air Quality Standard). Near sources  $\text{SO}_2$  concentrations are higher and may on occasion approach PSD allowable increments. The  $\text{SO}_2$  baseline date for Montana was established as of August 7, 1977, by the State Air Quality Bureau, and on March 3, 1979, by the U.S. Environmental Protection Agency.



In North Dakota,  $\text{SO}_2$  concentrations recorded by privately owned impact source monitoring sites show annual means to be less than  $5 \text{ ug/m}^3$  (6% of the Primary NAAQS). Highest 1-hour concentrations ranged from  $89 \text{ ug/m}^3$  to  $394 \text{ ug/m}^3$  (12% to 55% of the North Dakota Ambient Air Quality Standards). The 1979 air quality computer modeling estimates by the North Dakota State Department of Health indicated that the allotted 24-hour  $\text{SO}_2$  Class I PSD increment for the South Unit and the 3-hour  $\text{SO}_2$  increment for the North Unit of the Theodore Roosevelt National Park are nearly or already consumed.

There are a number of existing pollution sources in the Fort Union region, and the major point and area sources in the Montana half of the region include Montana Dakota Utilities (MDU), Shell Oil, Holly Sugar, Perry Petroleum, and Knife River Coal in Richland County, and the Valley County Industrial Park and KENCO in Roosevelt County. These sources emitted an estimated 4566 tons of  $\text{SO}_2$  and 671 tons TSP in 1980. Other Montana sources outside the Fort Union region, such as Montana Power Company's coal-fired power plants at Colstrip, also may impact the region's air quality (see Appendix B). The new Canadian power plant across the Montana border at Coronach also may affect the region's air quality.

In the North Dakota portion of the Fort Union region, there also are a number of major emission sources including the MDU Coyote plant, Basin Electric's Antelope Valley Stations I and II, the Warren Petroleum Company Gas Processing Plant, and various existing coal mines (see Appendix B). PSD permits are pending for the AMOCO Production Company, Minnesota Power & Light, Phillips Petroleum, an expansion of the Warren Petroleum facility, Nokota, and Basin Electric's Antelope Valley Station III. Another source proposed for the region includes the Great Plains Gasification plant.

In addition, there are an increasing amount of sour gas emissions associated with oil development in the region which result in  $\text{SO}_2$  and  $\text{H}_2\text{S}$  emissions where the gas is flared and used on lease. There are also TSP and other pollutant contributions from traditional area sources such as unpaved roads, agricultural field operations, open burning, construction activities, and vehicle exhaust.

## Visibility

Visibility in the Fort Union region is generally quite good, and in eastern Montana visibility ranges from 45 to 70 miles. In fact, visibility greater than 60 miles is common. At the Theodore Roosevelt National Park in western North Dakota, visibility in 1979 ranged from 73 to 96 miles. Significant reductions in the region's visibility are generally weather related.

Air pollution also may result in significant visibility reductions and the effects of such reductions include not only aesthetic degradation of the environment but also economic burdens on society.

There are two main types of visibility impairment which may be of concern in the Fort Union region, and they are atmospheric discoloration (plume blight) and visual range reduction (general haze).

Plumes from coal-fired power plants or other sources may be discolored due to nitrogen oxide ( $\text{NO}_x$ ) emissions that are converted to nitrogen dioxide ( $\text{NO}_2$ ) in the atmosphere. The  $\text{NO}_2$  may give the plume a reddish-brown color. Atmospheric discoloration due to  $\text{NO}_x$  emissions is greatest during periods of stable conditions with light winds following nighttime transport. However, since a plume tends to remain intact during such conditions, the discoloration would be confined to a small area (streak) in the sky.

Increased general haze, resulting in visibility reduction, is caused primarily by particulate emissions (TSP) and secondary aerosols, such as sulfates resulting from sulfur dioxide ( $\text{SO}_2$ ) emissions. General haze is greatest during light wind, limited mixing, or stagnation conditions after daytime transport. Under these conditions, conversion of gaseous precursor emissions to secondary aerosols is more rapid. Consequently, an individual plume may not be visible at all, but the general haze formed by regional emissions would cause decreased contrast and loss of clarity in the landscape.

Visibility reduction in the atmosphere due to manmade pollution is primarily caused by (1) light scattering by particles and (2) light absorption by particles and gases.

Particles suspended in the air reduce visibility, or visual range, by scattering and absorbing light coming from both an object and its background, thereby reducing the contrast between them. Moreover, suspended particles scatter light into the line of sight, illuminating the air between, to further degrade the contrast between an object and its background. Light scattering by particles is the most important cause of visual reduction, and particulates with diameters from 0.1 to 1.0 microns ( $\mu\text{m}$ ) are the most effective per unit mass in scattering light. Light absorption by particles also is significant when finely divided carbon particles (soot) are present.

Light absorption by gases also may be important to visibility in the Fort Union region because nitrogen dioxide ( $\text{NO}_2$ ), resulting from  $\text{NO}_x$  emitted by power plants and other sources, absorbs light. The  $\text{NO}_2$  absorbs light strongly at the blue end of the visible spectrum, while allowing light at the red end to pass through. In the atmosphere it reduces the brightness and contrast of distant objects, and causes the horizon, sky, and white objects to appear pale yellow to reddish-brown.

Congress has recognized the problem of visibility degradation and addressed it for mandatory Class I areas, or various national parks and other such federal lands, in the Clean Air Act of 1977. In Section 169A (a) (1) of the Act, Congress declared "as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas, which impairment results from man-made air pollution."

The Environmental Protection Agency subsequently has issued visibility regulations implementing the statute, which provide protection of visibility within Class I areas and also with respect to "integral vistas" associated with Class I areas (40 CFR 51.300 et. seq.). An "integral vista" is a view from within a Class I area, which is important to the visitor's visual experience of the Class I area itself. The National Park Service, Federal Land Manager for the Theodore Roosevelt National Park, has identified a number of integral vistas associated with that Class I area (Table 2-2). No final agency action, however, has been taken on those listings. Nor have any integral vistas been listed by the Fish and Wildlife Service, Federal Land Manager for the other Class I areas in or near the Fort Union Region.

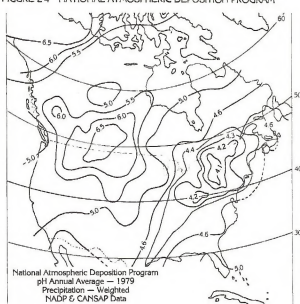
Class I visibility is protected under EPA regulations by requiring each affected state to develop a program to assure reasonable progress toward meeting the national goal of remedying existing and preventing future visibility impairment by manmade air pollution. Among other things, the visibility program must include requirements that certain existing major stationary sources of pollution affecting Class I visibility be retro-fitted with the best available technology to reduce such impacts, and that Class I visibility impacts of new major stationary sources or major modifications be reviewed as part of the PSD permit review process to ensure their emissions will be consistent with making reasonable progress toward the national visibility goal.

At the present time, neither Montana nor North Dakota has amended its state implementation plan to meet the federal Class I visibility requirements. Both states, however, have adopted an ambient air quality standard governing visibility in general (Appendix C).

## Acid Precipitation

Precipitation is naturally somewhat acidic (with a pH of about 5.6) because of the dissolution of atmospheric carbon dioxide to form carbonic acid. The term "acid precipitation" is generally applied to precipitation with a pH lower than 5.6, indicating that sources other than carbon dioxide cause the acidity. A whole number change in the pH value indicates a tenfold change in acidity. In most of the Fort Union Region, the annual precipitation pH average has been, at least until very recently, in the range of 6.0-6.5, or less acidic than expected for precipitation with atmospheric carbon

FIGURE 2-4 NATIONAL ATMOSPHERIC DEPOSITION PROGRAM



dioxide (National Atmospheric Deposition Program (NADP), 1970; North Dakota State Department of Health, 1977) (see Figure 2-4). However, current data being obtained in North Dakota indicate that precipitation is more acidic than could be caused by carbon dioxide (see discussion of acid precipitation in Chapter 3).

Although pH is an indication of acidity, the chemical composition of precipitation must be known to characterize the source of the acidity. Analyses of the chemical composition of acid precipitation over the eastern United States indicate the dominance of ions found in sulfuric acid and nitric acid; preliminary analyses of acid precipitation in the western United States suggest the dominance of ions found in nitric acid. Preliminary results from one investigation in Colorado suggest that precipitation with a pH of 4.6 may be infrequent and may be caused largely by the presence of nitric acid.

The precursors to the formation of sulfuric acid and nitric acid in the atmosphere are sulfur oxides and nitrogen oxides. Some of these undoubtedly come from fossil fuel combustion emissions, although quantitative relationships are still obscure. Some effects of the acidity are well recognized, but in this respect too, the relationships are obscure and controversial. Chemical transformations of gaseous sulfur dioxide to sulfuric acid and of gaseous nitrogen oxides to nitric acid are influenced by atmospheric conditions and may be enhanced by certain catalysts (e.g., vanadium, iron, manganese) and the presence of other pollutants such as ozone and reactive hydrocarbons.

The amount of acid deposited from the atmosphere has been of particular concern since the early 1950's when scientists determined that acid deposition was related to chemical and ecological changes in rivers and lakes in Scandinavia. Acidity and toxic substances (e.g., heavy metals) also have been observed to increase in many North American lakes and rivers,

TABLE 2-2  
Integral Vistas Associated with the Theodore Roosevelt National Park

Observation Point	View Angle	Key Feature	Also Viewed From
Badlands Overlook	353°-7°	Badland terrain	Johnson's Plateau, Painted Canyon, Ridgeline Nature Trail, Buck Hill
Bentonitic Clay	64°-94°	Killdeer Mountains, Long X Divide	Shelter Overlook
Boicourt-South	185°-248°	Bullion Butte, Square Butte	Buck Hill, Ridgeline Nature Trail, Johnson's Plateau
Boicourt-West	267°-298°	Camel's Hump, Twin Buttes	Ridgeline Nature Trail, Buck Hill
Buck Hill	0°-360°	Sentinel Butte, Square Butte, Camel Hump, Twin Buttes	Painted Canyon, Ridgeline Nature Trail, Johnson's Plateau, Badlands Overlook, Boicourt Ridge
Elkhorn Ranch Site	—	View of surrounding bluffs	
Johnson's Plateau-North	358°-54°	North Dakota Badlands	Badlands Overlook, Ridgeline Nature Trail, Buck Hill, Painted Canyon
Johnson's Plateau-South	117°-261°	DeMores Chateau, Bullion Butte, Square Butte, Sentinel Butte	Buck Hill, Ridgeline Nature Trail, Boicourt Ridge
Little Missouri	78°-110°	Custer National Grassland Plateau	Shelter Overlook
Man and Grass	226°-14°	Stock Butte, Little Missouri Grassland	
Medora Overlook	149°-250°	Theodore Roosevelt's Maltese Cross Cabin, DeMores Chateau, Little Missouri Town Site	
Oxbow	65°-224°	Killdeer Mountains, Achenbach Hills, Sperati Point	
Painted Canyon	303°-0°	Buck Hill, Little Missouri National Grassland	Ridgeline Nature Trail, Boicourt Ridge, Badlands
Ridgeline Nature Trail	0°-360°	Bullion Butte, Square Butte, Sentinel Butte, Camel's Hump, Twin Buttes	Johnson's Plateau, Buck Hill, Painted Canyon Overlook, Boicourt Ridge

Source: National Park Service, 43 Federal Register 3656 (January 15, 1981)

particularly in New England and southeastern Canada, over the past several decades. This increased acidity apparently has resulted in more than 100 fishless lakes in the Adirondack area of New York, more than 140 fishless lakes in the Canadian province of Ontario, and more than 15,000 fishless lakes in Sweden. Several thousand lakes in Minnesota and Wisconsin and 48,000 lakes in the province of Ontario are considered susceptible to increased acid levels.

Aquatic ecosystems are vulnerable to the effects of acid deposition in a number of ways. Increased river and lake acidity affects the hatching of fish eggs and the ability of young fish to survive, and the sudden injections of acid during the spring thaw from accumulations in winter snows can kill even mature fish. Acidification also may adversely affect amphibians and other components of the aquatic ecosystem such as aquatic plants and micro-organisms. Apart from the direct effects of increased acidity in the aquatic habitat, materials leached from surrounding soils by acidic solutions may be biological toxicants.

The effects of acid deposition on terrestrial ecosystems are not as certain or as easily quantifiable as the impacts on aquatic ecosystems because of the great number of species of plants and animals, the long time-frames of change in many ecosystems, and the complex inter-relationships among and between organisms and their environment. Some studies based on laboratory exposure to simulated acid precipitation have indicated that its effects on vegetation may include the leaching of important elements and compounds from the plant, increased vulnerability to plant pathogens, and higher susceptibility to drought.

Environmental sensitivity or tolerance to acid deposition varies from area to area. The sensitivity of lakes and rivers to acid deposition varies, depending on the buffering capacity (degree of alkalinity) of the surrounding soils. Vegetation in areas with acid-sensitive soils is considered particularly vulnerable. Soils in the Fort Union region, however, tend to be alkaline.

In addition to potential ecological harm, acid deposition has been linked by some studies to damage of building materials, painted surfaces, and statues. In the Fort Union region, the only recorded corrosive atmosphere problems occurred during the 1960's in the oil and sour gas production areas of the northwestern corner of North Dakota. Farm machinery and metal farm buildings were apparently damaged by sulfurous gases in combination with water vapor. These problems occurred prior to an air pollution control law in North Dakota, and industry voluntarily corrected them.

With respect to the potential impact of acid precipitation on human health, it is generally believed that there is little cause for concern over direct health effects from acid deposition since the pH of acidic precipitation is

generally well within the range normally tolerated by the skin and gastrointestinal tract. Some attention has been focused, however, on indirect health effects. There are two such effects often discussed, both involving the metals which can be dissolved and carried by water of greater than usual acidity. These are contamination of edible fish with mercury, and contamination of drinking water by heavy metals such as lead leached either from watersheds or from water storage and distribution systems. At the present time, the evidence to substantiate these concerns apparently is inconclusive.

It is important to note that considerable controversy surrounds the causes and effects of acid precipitation. A recent report by the General Accounting Office has attempted to clarify the actual areas of agreement and disagreement between the parties to the acid precipitation debate and to summarize the current state of scientific understanding of the issues (GAO, *The Debate Over Acid Precipitation*, EMD-81-131, September 11, 1981). Among the issues of particular interest for the Fort Union region are: (1) the relative contributions of natural and manmade pollution to acid precipitation; (2) the extent to which local versus distant sources are responsible for acid precipitation; and (3) the impacts of acid precipitation on the terrestrial ecosystem, including crops.

As previously noted, preliminary analyses of acid precipitation in the western U.S. indicate a higher level of nitric acid than sulfuric acid. Nitric acid may result from either natural or manmade sources. Lightning can form nitrogen oxides from the nitrogen and oxygen in the air, and other natural sources, such as wildfire, decomposing organic matter, and plant life release significant amounts of nitrogen compounds which can be converted to oxides in the atmosphere. Manmade sources include stationary sources such as fossil-fueled electric utilities and industrial plants, mobile sources using gasoline and other fossil fuels, and commercial and residential heating. Manmade non-energy sources also contribute nitrogen compounds from wind-blown agricultural fertilizers. The manmade  $\text{NO}_x$  emissions in the U.S. are quite substantial—almost as large as  $\text{SO}_2$  emissions. However, good estimates of  $\text{NO}_x$  emissions by natural sources are not available, so the relative shares of natural and manmade  $\text{NO}_x$  are not clear.

With respect to manmade pollutants contributing to acid precipitation, widespread disagreement also exists over the extent to which local versus distant sources are responsible for acid precipitation. Complex events in the atmosphere, both physico-chemical and meteorological, determine whether, where, and how much deposition occurs. At present, the relative rates and timing of transport, transformation, and deposition are not fully understood. Most research to date has focused on long-range transport of sulfur compounds from coal-fired power plants. Some recent reports, however,



argue that local combustion, particularly of residual home heating oil and fuel for motor vehicle sources, could be major contributors. Scientific work suggests that both contribute but has not firmly established the shares from each.

Finally, there is no clear consensus as to the potential impact of acid precipitation on crops. Most scientists say that more research is needed before we have an adequate understanding of the effects of acid deposition on terrestrial ecosystems. This contrasts with the general agreement among scientists that oxides of sulfur and nitrogen, ozone, and certain other gases can cause damage to vegetation, including economic damage to crops, when present in sufficient concentrations.

It is evident that the phenomenon of acid precipitation is extremely complex, and that it is a serious current problem in some parts of the world. Presently, there is no significant evidence of adverse effects due acid precipitation in the Fort Union Region. However, current studies being conducted by the North Dakota State Department of Health indicate that the possibility for adverse effects in the state due to acid precipitation may be greater than previously expected. This is due to the acidity of precipitation being found and to weak buffering capacity of some soils occurring within the state (for additional information, see Chapter 3).

## Regulation of Regional Air Pollution

Federal law for the control of air pollution has been evolving for over a decade. Congress passed the Air Quality Act, the first clean air legislation, in 1967. This was followed by the Clean Air Acts of 1970 and 1977 in which Congress reaffirmed its determination to cope with the growing national problem of air pollution. In 1982, Congress again is considering further amendments to its air quality legislation.

The Environmental Protection Agency (EPA) has the major federal role in ensuring compliance with the requirements of the Act. EPA issues national air quality regulations, approves and oversees state implementation plans, and conducts major enforcement actions.

State air pollution control agencies have the primary responsibility for carrying out the Act on non-Indian lands through the development and execution of an acceptable State Implementation Plan (SIP), which must provide for the attainment and maintenance of air quality standards within the state. The states of North Dakota and Montana both have EPA-approved State Implementation Plans.

With respect to Indian lands, EPA currently has air quality jurisdiction since it has not been given authority to delegate that responsibility to the states or to the

Tribes themselves. EPA, however, is assisting tribes within the Fort Union region, including the Fort Peck Reservation in eastern Montana and the Fort Berthold Reservation in western North Dakota, in the establishment of tribally operated air quality programs with ambient monitoring capabilities.

The basic regulatory framework of the present Clean Air Act involves National Ambient Air Quality Standards (NAAQS) and allowable increments for the Prevention of Significant Deterioration (PSD) of air quality.

## National Ambient Air Quality Standards

NAAQS are absolute, nationwide limits on the amount of certain pollutants which may be present in the air. No part of the country may exceed these levels. The federal government has set primary standards to protect public health and secondary standards to protect the general public welfare. The states of North Dakota and Montana have set their own ambient standards for the same pollutants, which are at least as stringent as the federal standards (Appendix C).

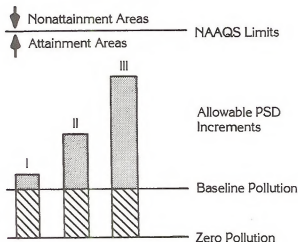
To enforce the NAAQS requirements, all parts of the country have been classified as (1) an "attainment" area where air quality levels are better than the NAAQS limits, (2) a "nonattainment" area where pollution levels in the air exceed the NAAQS limits, or (3) an "unclassifiable" area where there is insufficient data to classify them. Nonattainment areas, typically urban, are subject to regulatory requirements designed to bring area pollution levels down to the NAAQS ceiling. No part of the Fort Union region is classified "nonattainment" for any pollutant. Attainment and unclassifiable areas, or all of the Fort Union region, are subject to PSD requirements.

## Prevention of Significant Deterioration

The PSD program is designed to protect the air quality from significant deterioration in areas already meeting the NAAQS. In other words, they allow a specific increase or "increment" in pollution, over and above the existing air quality "baseline" pollution levels, in cleaner areas. In no event, however, may pollution increases exceed the NAAQ (Figure 2-5).

The size of the increment allowable under the PSD program depends on the area's designation as a Class I, II, or III area, with Class I areas allowed the smallest pollution increment and Class III the largest (Table 2-3). In the 1977 Act, Congress designated certain national parks and other such areas as Class I areas. All other areas were designated Class II. Congress, however, provided a procedure for state and tribal governments to redesignate areas under their jurisdiction as Class I or II.

FIGURE 2-5 INTERACTION OF NAAQS AND PSD STANDARDS



Source: GeoResearch, Inc. 1981.

TABLE 2-3  
Federal and State PSD Increments ( $\mu\text{g}/\text{m}^3$ )

Deterioration Increments for Area Designations	Federal and Montana	North Dakota
<b>Particulates</b>		
Class I		
annual geometric mean	5	5
24-hour maximum	10	10
Class II		
annual geometric mean	19	10
24-hour maximum	37	30
Class III		
annual geometric mean	37	37
24-hour maximum	75	75
<b>Sulfur Dioxide</b>		
Class I		
annual arithmetic mean	2	2
24-hour maximum	5	5
3-hour maximum	25	25
Class II		
annual arithmetic mean	20	15
24-hour maximum	91	91
3-hour maximum	512	512
Class III		
annual arithmetic mean	40	40
24-hour maximum	182	182
3-hour maximum	700	700

Sources: Title 40 CFR, Part 51; Administrative Rules of Montana, 16-8-904, 1979; Chapter 33-15-15 NDAC.

North Dakota's PSD increments are somewhat more stringent than the federal standards with respect to Class I areas. Montana's PSD increments are identical to the federal standards. Montana's PSD program has not been approved yet by EPA, however, Montana presently is in the process of amending its program to secure such approval. The applicable PSD increments for the two states are set forth in Table 2-3.

PSD requirements are enforced by a complex pre-construction permit system for major new stationary pollution sources and for major modifications to existing sources. The PSD permit process involves the study of existing air quality, requirements for the use of best available pollution control technology, and various impact studies to ensure that PSD standards (established thus far only for particulate matter and sulfur dioxide) will not be exceeded by allowing the pollution source to operate in the area.

If the PSD source is to be located near a Class I area, it may not exceed the PSD standards nor have any adverse impact on the air quality-related values (including visibility) of the Class I area. Visibility, as previously noted, is protected both within the Class I area itself and also with respect to "integral vistas" extending outside the Class I boundary.

If a proposed PSD source cannot satisfy the maximum allowable deterioration increments for a mandatory Class I area, it may have an opportunity to seek a waiver or a variance. Under Federal and North Dakota law, three possible variance routes are open to such a source, involving the Federal Land Manager of the Class I area, the Governor of the State, and possibly the President of the United States (Section 165 (d)(2)(C) and (D) of the Clean Air Act; North Dakota State Department of Health, Air Pollution Control Regulations 1978). The state of Montana regulations presently do not afford variances from Class I PSD requirements; however, Montana's Air Quality Bureau has proposed regulations which would provide them. Montana does have variance procedures involving the Governor under the Federal Clean Air Act as mentioned above.

If a new emission source is not sufficiently "major" to require a PSD permit, it nonetheless must obtain a permit or otherwise comply with other applicable air quality standards.

In North Dakota, air quality permits generally are required to construct and to operate a facility which may issue an air contaminant into the ambient air. The purpose of the Permit to Construct and the Permit to Operate is to regulate air pollution sources to assure compliance with the various ambient and emissions requirements of the Federal Clean Air Act and the State Air Pollution Control Law (North Dakota Air Pollution Control Law, Chapters 23 through 25, NDCC; Article 33-15, North Dakota Administrative Code.)

In Montana, a permit from the Department of Health & Environmental Sciences is required for the construction, installation, and operation of equipment of facilities that may directly or indirectly cause or contribute to air pollution (Montana Clean Air Act, 75-2-211, 212, 301, MCA; 16.8.1101 *et seq.*, ARM). Exceptions include residential heating units, food service establishments, ventilating systems, motor vehicles, trains, aircraft, road construction (except stationary sources) and other sources which emit less than specified amounts. The city or county may administer its own air pollution permit program in addition to the Department's permit program. Montana air quality permits to construct or operate a new or altered air pollution source cannot be issued unless the source is able to comply with the ambient air quality standards, emission limitations, and other rules adopted under the Montana Clean Air Act, and the applicable regulations and requirements of the Federal Clean Air Act.

### Fort Union Air Classification Areas

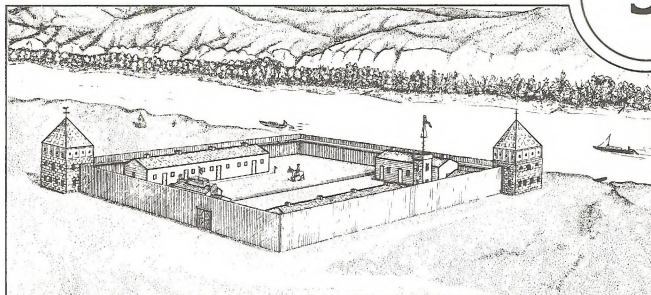
All of the Fort Union region currently is designated Class II, with the exception of Congressionally mandated Class I areas including: Theodore Roosevelt National Park in McKenzie and Billings counties in southwestern North Dakota; Lostwood National Wilderness Area in Burke County, North Dakota; and Medicine Lake Wilderness Area in Sheridan County, the northeasternmost part of Montana. Two other federal

Class I areas which are just outside the Fort Union region are the Northern Cheyenne Indian Reservation and the UL Bend Wilderness Area. The UL Bend Wilderness Area is located near the confluence of the Missouri and Mussellshell Rivers in Phillips County, Montana, and the Northern Cheyenne Indian Reservation is located in Big Horn and Rosebud Counties, Montana. In addition, the Fort Peck Indian Reservation in Daniels, Valley, Roosevelt, and Sheridan counties of northeastern Montana, has notified the Bureau of Land Management that redesignation of reservation air quality to Class I status is under active consideration.

Due to the small amount of incremental pollution allowed under Class I standards, the greatest air quality regulatory constraint on new development in the Fort Union region most likely will be regulatory compliance within these PSD Class I areas. According to computer dispersion modeling analyses conducted by the State of North Dakota, the PSD SO<sub>2</sub> 24-hour increment for the South Unit of the Theodore Roosevelt National Park already has been consumed or nearly consumed, and the 3-hour SO<sub>2</sub> increment has been largely consumed for the North Unit by previously permitted PSD sources. This represents a potential constraint on the siting of new facilities emitting SO<sub>2</sub> in western North Dakota.

The PSD regulatory picture at Theodore Roosevelt National Park also may be further complicated if visibility protection is provided for a number of potential integral vistas extending outside the park's boundaries (see Table 2-2).





## ENVIRONMENTAL CONSEQUENCES

### AIR QUALITY AND CLIMATE INTRODUCTION

Air pollutants will be emitted into the atmosphere as a direct consequence of the project. The major air pollutants which will be emitted are particulates, sulfur dioxide and nitrogen dioxide. The estimated quantities of these emissions, in terms of hourly emission rates corresponding to each of the project alternatives, are shown in Table 3-1.

In addition to these major air pollutants, many other pollutants will be emitted in relatively small amounts. These include carbon monoxide, hydrocarbons, and trace element species.

The environmental consequences of these air pollutant emissions will be extensive and complex. The direct consequences related to each tract have been analyzed and reported in the individual site specific analyses (BLM, 1981a).

Evaluation of cumulative regional effects requires analysis by advanced computer modeling. A modeling study was therefore carried out to evaluate cumulative effects on ground-level concentrations of major air contaminants which can be expected to result from the project in its various alternative forms.

The modeling study plan was cooperatively developed by the BLM, its contractor (ECOS Management Criteria, Inc.), the subcontractors (GeoResearch, Inc., and Science Applications, Inc.), the North Dakota State

Department of Health (NDS DH), the Montana Air Quality Bureau (MAQB), and the U.S. Environmental Protection Agency (EPA), Region VIII.

The modeling study included determination of worst-case ground level concentrations of the above major air pollutants and of sulfates, a secondary pollutant deriving from sulfur dioxide. The resulting pollutant concentrations were compared with state and federal air quality standards to show the extent to which the standards could potentially be exceeded (violated) as a consequence of the project. Incremental pollutant concentrations were also compared with increments allowable under regulations for prevention of significant deterioration of air quality to show the extent to which these regulations could be violated. Effects of the air pollutants on visibility were also modeled. Other cumulative effects of the project on air quality, which cannot be as thoroughly quantified, were also investigated.

The principal results and conclusions of these studies, together with summary descriptions of the assumptions and methodologies employed, are given in the following sections. Complete technical details are given in a separate Technical Report (ECOS Management Criteria, Inc., 1982). It was recognized by the groups planning the study that it could not be sufficiently extensive and thorough to be completely definitive of all potential air quality effects of all project alternatives because of both time and budgetary limitations. Specific limitations of the analysis and of the conclusions which can be drawn from it are pointed out in a later section (Limitations of the Modeling Studies).

**TABLE 3-1**  
**Project Source Emissions Estimates (pounds per hour)**

	TSP			SO <sub>2</sub>	NO <sub>2</sub>
	Mine Facilities	Conversion Facilities	Total	Conversion Facilities	Conversion Facilities
Alternative 1	3,455	0	3,455	0	0
Alternative 2	7,812	1,222	9,034	11,783	10,576
Alternative 3	10,954	1,996	12,950	32,373	33,536
Alternative 4	12,218	2,196	14,414	32,043	29,896
Alternative 5	13,686	3,146	16,832	44,173	38,336
Alternative 6	16,087	4,656	20,743	65,424	54,316
Meridian Exchange	12,039	2,108	14,147	34,973	37,956
Woodson PRLA	11,531	2,371	13,902	39,903	39,176

## REGIONAL AIR QUALITY MODELING ANALYSIS

The modeling study was designed to assess worst-case cumulative effects upon regional air quality from BLM proposed leasing and from all other existing and planned emission sources within the Fort Union Coal Region. The principal project-related sources of air pollutant emissions included in the modeling study are the coal mines (one surface mine for each lease tract) and assumed conversion facilities (one for each tract) which would utilize the coal mined for production of either electric power or synthetic liquid or gaseous fuels. It was assumed that all proposed surface mines and end-use facilities would be fully operational by the year 1997. The area which was modeled extends slightly beyond the edges of the regional map in Figure 3-1. The figure delineates the modeled mining tracts. Emphasis was placed upon determination of incremental pollutant concentrations and their evaluation versus regulatory limits for prevention of significant deterioration (PSD) at mandatory Class I areas. The Class I area of greatest concern is the Theodore Roosevelt National Park (TRNP) (North and South Units and Elkhorn Ranch). Class I and other sensitive receptor areas are shown in the figure. These include the Medicine Lake National Wildlife Refuge, the Lostwood National Wildlife Refuge, the Fort Peck Indian Reservation and the Northern Cheyenne Indian Reservation. PSD increments in Class II areas are also assessed; these encompass the entire study area with the exception of Class I areas. Another objective of the modeling study was to estimate worst-case pollutant concentrations along integral vistas at TRNP for use in the assessment of adverse effects upon visibility.

## Methodologies and Assumptions

### Emissions

The only pollutants emitted in significant amounts by coal mining and end-use facilities are total suspended particulates (TSP), sulfur dioxide (SO<sub>2</sub>), and nitrogen oxides (NO<sub>x</sub>). There is no ambient air quality standard (AAQS) for NO<sub>x</sub>; however, it was assumed that all NO<sub>x</sub> would be fully oxidized in the atmosphere to nitrogen dioxide (NO<sub>2</sub>) for which AAQS have been established.

Similarly, SO<sub>2</sub> is oxidized in the atmosphere to sulfates (SO<sub>4</sub>) by complex, and only partially understood, chemical processes. It is known that secondary pollutants, such as NO<sub>2</sub> and SO<sub>4</sub>, have adverse effects upon visibility. Therefore, an empirical conversion of primary SO<sub>2</sub> to secondary SO<sub>4</sub> was incorporated into the modeling methodologies to complete the visibility assessment.

Five alternatives are being evaluated for proposed coal resource leasing in the Fort Union Region. These alternatives consist of different combinations of the mining tracts shown in Figure 3-1. Another alternative (No. 1) represents the "No-Action Alternative" and involves continuing production of existing mines and utilization of by-pass resources on BLM-managed lands. Emission rates for mining and conversion facilities, as used in modeling Alternatives 2 through 6, are listed in Appendix E, which also lists the types of conversion facilities for each alternative.

Two non-project emission inventories were compiled (Appendix F). One inventory represents sources which existed in 1975 (the starting year of the North Dakota PSD program). The second inventory includes emission rates and parameters for sources developed after

## MONTANA NORTH DAKOTA

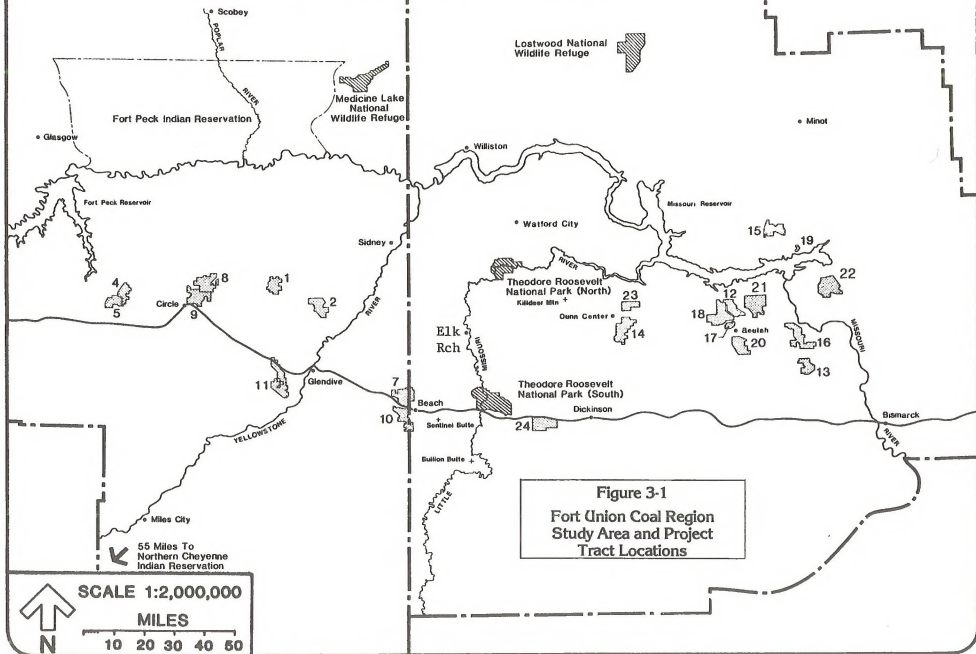


FIGURE 3-1 (cont.)

## PROJECT TRACT IDENTIFICATION

1. Bloomfield	13. Center
2. Burns Creek	14. Dunn Center
3. Central Bloomfield	15. Garrison
4. Circle West I	16. Glenharold
5. Circle West II	17. North Beulah
6. Circle West III	18. Renner
7. North Wibaux-Beach	19. Sakakawea
8. Redwater I	20. Schoolhouse
9. Redwater II	21. Truax
10. South Wibaux-Beach	22. Underwood
11. Southwest Glendive	23. Werner
12. Antelope	24. Zenith

1975 and applicable to PSD modeling and analysis of increment consumption. Emission sources under Alternative 1 are included in this inventory. In addition to these and other existing PSD sources, the inventory also incorporates emission sources whose PSD permit applications are currently under review by regulatory agencies. For analysis purposes, these sources are assumed to be fully operational by the year 1997 when BLM-proposed mining and end-use facilities are planned to be on-line.

Other major sources near the Fort Union Coal Region, such as the Colstrip and Poplar River power plants, are also included in this 1997 baseline inventory since they could impact regional air quality. Air pollutant concentrations from these 1997 baseline sources at PSD Class I and II areas are included in determining the level of consumption of allowable increments. Sources in the 1975 baseline inventory were established prior to the PSD permitting program, and therefore, their impacts are only considered in the assessment of potential violation of federal and state ambient air quality standards.

#### Short-Period Modeling

Averaging times, which are defined in applicable federal and state AAQS and PSD regulations (see Appendix C), are 1-hour, 3-hours, 24-hours and annual averages. The assessment of short-period averages (i.e. 1, 3 and 24 hours) was performed with the MESOPUFF (Mesoscale Puff) model. MESOPUFF was adapted by the NDS DH for regional assessments in North Dakota and was approved in a recent NDS DH guideline for long-range air quality analysis (NDS DH, 1982). Modeling procedures described in the guideline are to be followed when assessing air quality impacts from emission sources in North Dakota. The NDS DH version of MESOPUFF was modified by the ECOS study team to model both point and area source emissions and to simultaneously predict impacts for the four modeled pollutants throughout the study region.

Historical meteorological conditions chosen for modeling were those anticipated to produce maximum

adverse impact from anticipated mining and conversion facilities emissions. Modeled meteorological scenarios were selected from the data base established by the NDS DH for the year 1964. Earlier modeling studies conducted by the NDS DH indicated that meteorological conditions on July 3-6, 1964, result in consumption of the 24-hour maximum increment for sulfur dioxide at TRNP-North Unit by existing sources and those for which PSD permit applications are pending. The present analysis indicated that proposed project sources of Alternative 6 may also result in significant impacts at TRNP during the December 3-5, 1964, episode. On this basis, the five leasing alternatives were modeled for short-period concentration averages using the above-listed meteorological conditions. Three meteorological scenarios were constructed, each having a duration of 48 hours, that is, July 3-5, July 4-6, and December 3-5. Each 48-hour modeling period began and ended at 1200 Greenwich Mean Time (GMT), which is 0600 Central Standard Time (CST). It is noted that other meteorological episodes not considered in this study could lead to consumption by existing and pending PSD sources of PSD Class I increments for sulfur dioxide at other Class I areas in the Fort Union Coal Region. As an example, the NDS DH found that 1997 baseline sources can result in consumption of the 24-hour average SO<sub>2</sub> increment at the TRNP-South Unit during the January 10-12, 1964, episode. For the selected modeling scenarios, meteorological data provided by NDS DH were prepared for MESOPUFF modeling with its preprocessor, called MESOPAC. The procedures and modeling grids are described in Appendix G.

#### Modeling of Annual Average Concentrations

The EPA-approved Climatological Dispersion Model (CDM/QC) was used to estimate annual average concentrations of SO<sub>2</sub>, TSP and NO<sub>2</sub> which would result from each alternative and the existing sources. CDM/QC was modified for this project to treat particulates fallout for mining emissions and rural dispersion conditions. The model uses the average of joint frequencies of wind speed, wind direction and atmospheric stability



recorded at Bismarck, Dickinson, Minot and Miles City.

Both the MESOPUFF and CDMQC models have been used in various air quality modeling studies involving coal resources development. However, they have not been thoroughly validated for such assessments. It is generally accepted that impact predictions by these models are accurate to within a factor of two. The MESOPUFF and CDMQC models are briefly described in Appendix G. Detailed descriptions are provided in Appendix A of the technical report.

#### Pollutant Background Concentrations

To evaluate the effects of project pollutant emissions, particularly in relation to federal and state air quality standards, it is necessary to know the pre-existing, or background, concentrations of the pollutants. Although a considerable body of air quality monitoring data are available for locations in the Fort Union Coal Region, as given in the section on Air Quality in the Affected Environment, the quantity and quality of data suitable for use to establish background concentrations are sparse, spotty and incomplete. The monitoring data employed in determining regional background concentrations were selected from the available data on the basis of the following criteria:

- Data obtained in rural areas affected minimally by human activities and pollutant emissions,
- Data obtained over an extended period of years,
- Data for different pollutants obtained at the same locations,
- Data representing different geographical locations throughout the region,
- Data unaffected by any known major perturbations, human-caused or natural, such as the Mt. St. Helen's volcanic eruption episode of May, 1980.

The data were obtained at the following locations during the years shown:

Lake Tschida, ND (1976-79)  
Medora, ND (1978-81)  
TRNP (North), ND (1978-81)  
Beach, ND (1980-81)  
Dunn Center, ND (1980-81)  
Foxholm, ND (1958-76)  
Scobey, MT (1980-81)  
Four additional sites in Montana for TSP

The regional pollutant background concentrations which were found on the basis of the above criteria and monitoring data are shown in Table 3-2 and are used in evaluating the modeling results in the following sections of the report.

TABLE 3-2  
Estimated Ambient Pollutant Background  
Concentrations in the Fort Union Coal Region

Pollutant	Concentration ug/m <sup>3</sup> <sup>1</sup>
Sulfur dioxide	
Maximum annual arithmetic mean	3
24-hour maximum	9
3-hour maximum <sup>2</sup>	27
1-hour maximum	82
Total Suspended Particulates	
Maximum annual geometric mean	20
24-hour maximum	130
Nitrogen Dioxide	
Maximum annual arithmetic mean	9
24-hour maximum	32
1-hour maximum	42

<sup>1</sup>ug/m<sup>3</sup> — micrograms (of pollutant) per cubic meter (of air)

<sup>2</sup>Estimate based on rough interpolation between 1-hour and 24-hour maxima; no monitoring data are available for 3-hour maxima.

#### Limitations of the Modeling Studies

The modeling studies show the potential worst-case adverse consequences of the project on air quality in terms sufficient to provide an understanding of the types of adverse effects to be expected, their geographical extent, their degrees of intensity, and their relationships to regulatory standards. This information can be used to aid in selection of a preferred alternative, and to anticipate the nature of its impacts. It can also be used as a guide to more detailed future evaluation of the selected alternative and of its specific implementation features.

It must be understood, however, that the modeling studies were limited by various constraints, and the conclusions are consequently subject to limitations which should be borne in mind by the reader.

Only worst-case situations were evaluated, because these are the most important in determining acceptable project limits. However, the worst-case results give no quantitative information on average impacts, or on best-case situations, or on frequencies to be expected for worst, average, best, or any other circumstances.

The worst-case scenarios evaluated are themselves also subject to limitations. Since air pollution characteristics are largely determined by meteorological conditions, it was necessary to select and employ meteorological scenarios representing worst-case meteorology, but the meteorological scenario that is worst for one

geographical area may or may not be worst for another area. The area for which worst-case meteorological scenarios were selected for this study was Theodore Roosevelt National Park (TRNP) for the obvious reasons of its status as a PSD Class I area located virtually in the middle of the Fort Union Coal Region. Therefore, while the modeling studies represent worst-case impacts for TRNP, and may also represent worst-case impacts for other areas in the region, such as the Indian reservations and wildlife refuges, the latter assumption is less than certain. Thus, for any other specific location in the region, there could be worse air quality impacts than these studies show.

Furthermore, the meteorological scenarios, in order to represent real rather than hypothetical meteorology, were selected from actual meteorological records for a particular year. The particular year chosen was 1964, for the reasons that meteorological records for that year are the best (most complete and detailed) available. Also, and for the same underlying reason, the NDSHD had already performed various air quality modeling studies utilizing 1964 meteorological data, and it was advisable for the present study to utilize the same data base for correlation as well as convenience. However, the possibility remains that a worse meteorological episode could occur in some future year than the worst in 1964, leading to worse air quality impacts than these studies predict. It should also be noted that where the following discussions describe air quality effects for particular calendar dates (e.g. July 4-5, December 3-4, etc.), these refer to the worst-case meteorological scenarios based on 1964 data but do not imply any prediction of calendar dates on which worst-case impacts will occur in any future year.

The 1964 meteorological data, while the best available, are none too good for air quality modeling purposes. There are only two locations (Bismarck and Glasgow) within the entire study region for which upper level meteorological data are available, and these data are relatively infrequent (two per day). The upper level winds (their direction, velocity, and temperature) are important, as they are the primary factors determining dispersion and transport of air pollutants. This sparsity of meteorological data limits the accuracy and reliability of results obtainable by modeling.

The modeling runs were also subject to limitations as to the number and length of scenarios which could be performed consistent with the technical objectives as well as the time and cost constraints of the study.

Finally, the mathematical models employed in the study have their own limitations, being based on physical-chemical-mathematical theory. However, they represent the current state of the art and are recognized as useful predictive tools by both scientists and government agencies. Limitations and assumptions pertaining to the models are discussed in the preceding section.

## Modeling Results and Potential Adverse Impacts

Regional air quality was modeled with emissions representing each of the two non-project baselines (1975 and 1997 sources). Pollutant dispersion was also modeled for each leasing alternative for each averaging period. The resulting pollutant concentrations for each alternative were added to those for the baselines at each point in the modeling grid covering the geographical area. The estimated background concentration for each pollutant and averaging period was then added uniformly to these concentration fields for evaluation relative to the AAQS. North Dakota and Montana have different ambient air quality standards for sulfur dioxide, particulates and nitrogen dioxide, which are the same or more stringent than the federal standards (Appendix C).

### Assessment of Ambient Pollutant Concentrations Relative to Ambient Air Quality Standards

Modeling of cumulative TSP 24-hour averaged concentrations indicates that both the state and federal secondary standards can be exceeded for each of the five leasing alternatives. The cases for which AAQS exceedances are predicted by modeling are summarized in Table 3-3. Note that state standards in both Montana and North Dakota, as well as the federal secondary standard, are exceeded in all cases. The higher federal primary standard is exceeded only by Alternative 6, which represents the maximum coal mining and conversion case and, therefore, causes the highest exceedance. It should also be noted that the North Dakota standard and the federal secondary standard, both  $150 \text{ ug/m}^3$ , are only  $20 \text{ ug/m}^3$  above the ambient background concentration of  $130 \text{ ug/m}^3$  allowing very little margin for particulate emissions from any non-natural source.

The geographical distribution of TSP pollution is illustrated in isopleth maps which were generated for each pollutant during each day of the July 4-6 and December 3-5 episodes. For the July 3-5 episode, the MESOPUFF model was exercised to calculate concentrations only at specific receptor points in Class I areas; therefore, isopleth maps were not generated for this episode. Each 24-hour averaging period started at 0600 CST on the specified day. The highest concentrations within the modeling grid were produced on the second day of the December episode. Figures 3-2 and 3-3 display total TSP concentration contours for the two days, respectively, for Alternative 6 emissions. Four contour levels were used in the analysis: one (labeled A) is only  $4.5 \text{ ug/m}^3$  over the assumed background value of  $130 \text{ ug/m}^3$ ; contour B is set just below the federal secondary and North Dakota 24-hour average standards; contour D is approximately equal to the federal primary TSP standard; and contour C is set midway between contour values B and D. A plot of contour D occurs only

in Figure 3-3. This level has an extent of only one grid cell and, hence, may be within the boundaries of the mining tract. The AAQS are not applicable within the mine boundaries.

Figure 3-4 presents the 1997 TSP baseline concentrations for the second day of the December 3-5 episode. Since predicted impacts from 1975 baseline sources are insignificant, their isopleths are not reproduced in this document. From Figures 3-3 and 3-4, it can be seen that the 1997 baseline isopleths have very little overlap with Alternative 6 isopleths. The strong localization of isopleths near the tract sources results from the fallout of TSP relatively close to sources. The violation of the federal primary air quality standard in Montana results from modeled project emission sources; while the violation in North Dakota results from 1997 baseline emission sources, as well as project sources. (This does not show up in the data presented in Table 3-3, as the data in the table refer to locations of maximum concentration from project plus baseline sources, which do not coincide with locations of maximum concentration from baseline sources alone.)

Modeled 24-hour average sulfur dioxide concentrations, plus baseline and background concentrations,

range from 8 percent (Alternative 4 in Montana) to 23 percent (Alternative 6 in Montana) of North Dakota and Montana standards (260 micrograms per cubic meter,  $\mu\text{g}/\text{m}^3$ ). The federal standard is  $365 \mu\text{g}/\text{m}^3$ . Hence, no violation of ambient 24-hour  $\text{SO}_2$  standards is predicted.

Figure 3-5 presents cumulative isopleths for Alternative 6, baseline and background concentrations during December 4-5 meteorology. This represents the highest case for  $\text{SO}_2$  concentrations. The zone of impact is larger for sulfur dioxide than for particulates because it is mainly emitted from elevated stacks as a buoyant gas. All contoured concentrations are less than 24-hour average federal and state AAQS. This finding also applies to other alternatives, since Alternative 6 represents the maximum development of potential mining tracts.

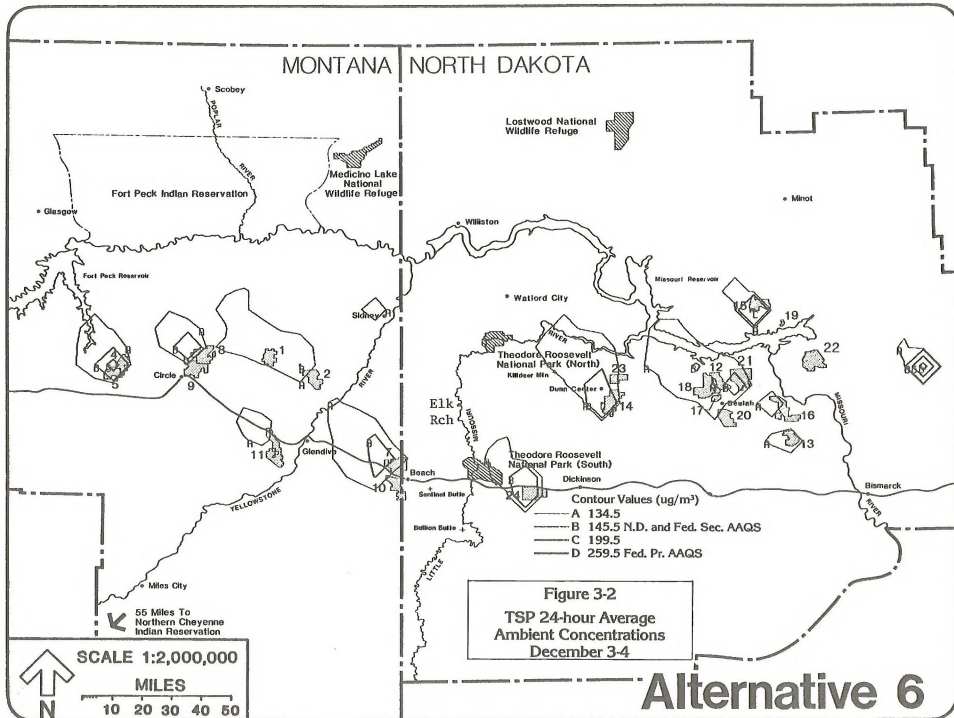
One-hour and three-hour  $\text{SO}_2$  modeled concentrations (plus baseline and background values) are even smaller fractions of the applicable AAQS than the 24-hour averages. The modeled 1-hour average  $\text{NO}_2$  values range up to 56 percent of the North Dakota  $\text{NO}_2$  standard ( $200 \mu\text{g}/\text{m}^3$ ) for Alternative 2. The maximum value in Montana ( $306 \mu\text{g}/\text{m}^3$  for Alternative 6) represents half of the state AAQS ( $600 \mu\text{g}/\text{m}^3$ ).

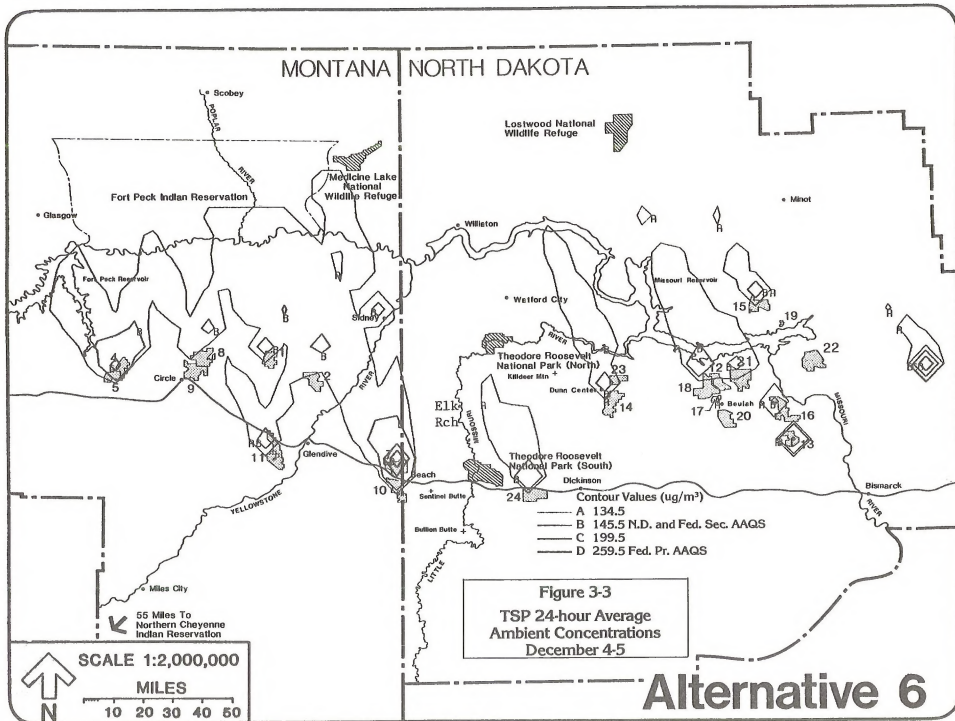
TABLE 3-3  
Ambient 24-hour Average TSP Concentrations Exceeding Standards  
Pollutant concentrations in micrograms (of pollutant) per cubic meter (of air)

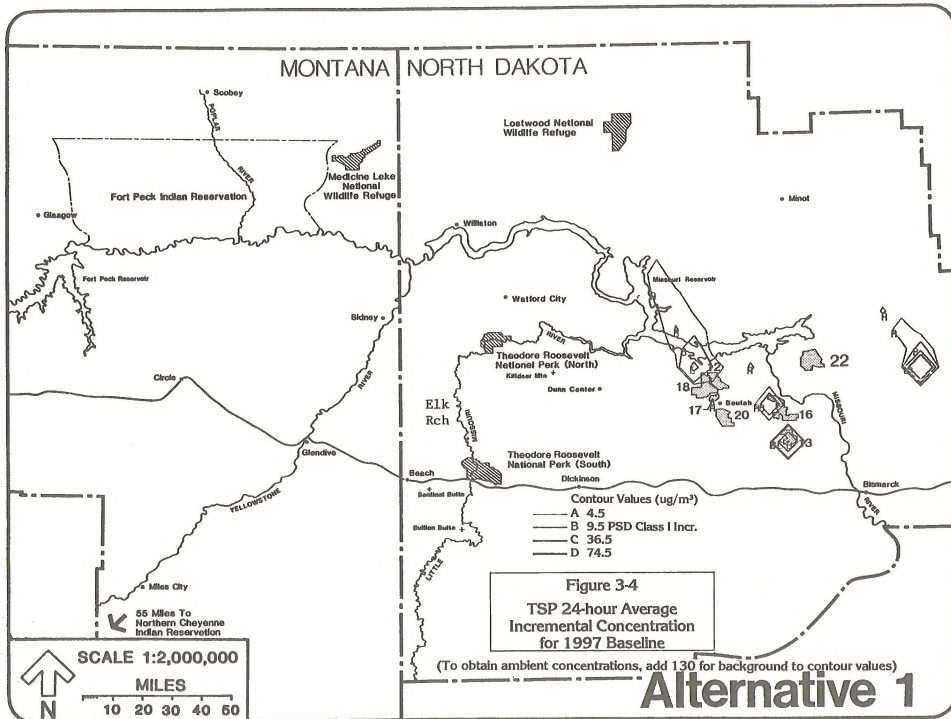
Background	Baseline 1975-1977	Alternative	Total	Ambient Air Quality Standards		
				Federal <sup>1</sup>	Montana	North Dakota
MONTANA						
130	0	2	250	260 (150)	200	
		3	220			
		4	209			
		5	250			
		6	330			
NORTH DAKOTA						
130	1	2-6	206	260 (150)		150

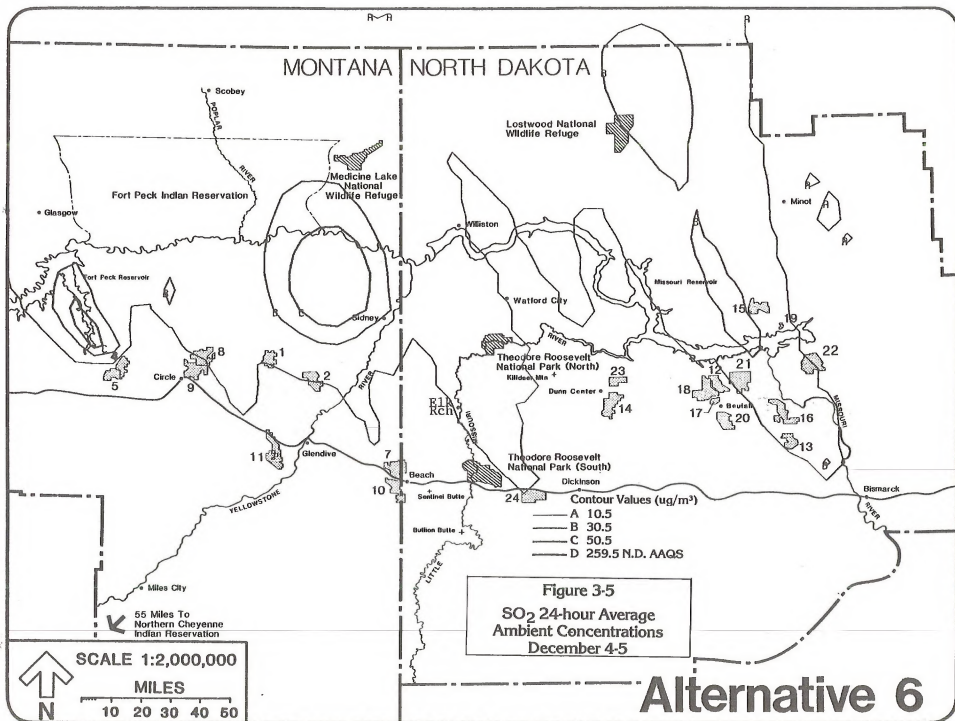
<sup>1</sup>Numbers in parentheses denote the federal secondary standard.











### Assessment of Ambient Pollutant Concentrations Relative to Annual Average Ambient Air Quality Standards

Modeled annual average project plus baseline and background concentrations are less than the annual AAQS for all pollutants and all alternatives. No violations are predicted. Table 3-4 summarizes the modeled ranges in these values for the various alternatives. The table lists maximum values for each modeling and baseline case; these do not necessarily occur at the same geographical locations. Therefore, the column for total concentrations is an upper limit or overestimation.

### Assessment of Incremental Pollutant Concentrations Relative to PSD Class I Standards

Increments from 1997 baseline emissions are added to modeled increments for each project alternative. Increments were modeled for Class I and II areas in the region (refer to Table 2-5 in Chapter 2 and accompanying text for explanation of PSD regulations). Annual and 24-hour average increments for TSP and SO<sub>2</sub> were calculated. The three-hour average increments for SO<sub>2</sub> were also modeled.

Table 3-5 lists modeling cases which result in incremental pollutant concentrations exceeding the allowable federal and state PSD Class I increments. The allowed 24-hour average increment (5 ug/m<sup>3</sup>) is exceeded in the North Unit of Theodore Roosevelt National Park (TRNP-N) for Alternatives 3 through 6 during the July 3-5 episode. These alternatives include project tracts at Dunn Center and Werner which are southeast of TRNP-N. Prevailing wind from the southeast, as recorded at Bismarck during the episode, results in modeled concentrations of 8.48 ug/m<sup>3</sup> (Alternative 4) through 8.60 ug/m<sup>3</sup> (Alternatives 3 and 6). These are in excess of the allowed increment; and when combined with modeled increments for 1997 baseline sources near TRNP-N, the total of 21 ug/m<sup>3</sup> considerably exceeds the allowed increment. Sources in the 1997 baseline, which do not include BLM-proposed projects, also result in increments (12.8 ug/m<sup>3</sup>) in excess of the allowed limit. This indicates that the allowable 24-hour increment for sulfur dioxide at the North Unit of TRNP is totally consumed (and exceeded) by existing and pending PSD sources.

TABLE 3-4  
Maximum Annual Average Pollutant Concentrations  
Pollutant concentrations in micrograms (of pollutant) per cubic meter

Pollutant	Background	Maximum 1975 Baseline	Maximum 1997 Baseline	Maximum Project	Maximum Total	AAQS	
						Federal <sup>1</sup>	State <sup>2</sup>
Sulfur dioxide <sup>3</sup>	3.0	13.7	4.1	0.5-2.5	20-23	80	60
TSP <sup>4</sup>	20.0	5.6	10.4	5.9-11.9	36-48	75 (60)	60
Nitrogen dioxide <sup>3</sup>	9.0	4.6	6.2	0.5-1.9	16-22	100 (100)	100

<sup>1</sup>Numbers in parentheses denote the federal secondary standard.

<sup>2</sup>The most stringent standard of Montana and North Dakota.

<sup>3</sup>Annual arithmetic mean.

<sup>4</sup>Annual geometric mean.

**TABLE 3-5**  
Incremental Pollutant Concentrations Exceeding PSD Class I Standards  
All pollutant concentrations in units of ug/m<sup>3</sup>

Class I Area	Pollutant	Period	Allowable PSD Increment		Episode	1997 Baseline	Alternative	Project	Total
			Federal	State		Consumption			
TRNP-N <sup>1</sup>	SO <sub>2</sub>	24-hour	5	5	July 3-4	12.8	3-6	8.5-8.6	21
					Dec. 3-4	2.7	4-6	3.7	6.4
	SO <sub>2</sub>	3-hour	25	25	July 3-4	17.7	3-6	17.4	35
TRNP-S <sup>2</sup>	SO <sub>2</sub>	24-hour	5	5	July 3-4	0.5	4-6	5.7	6.3
Lostwood <sup>3</sup>	SO <sub>2</sub>	24-hour	5	5	July 3-4	2.6	3-6	3.0-3.2	5.5-5.7
					Dec. 3-4	7.5	2-6	0.4-4.3	7.9-11.8
Fort Peck <sup>4</sup>	SO <sub>2</sub>	24-hour	5 <sup>5</sup>	5 <sup>5</sup>	Dec. 3-4	0.08	5-6	14.3	14.4

<sup>1</sup>Oxbow Overlook

<sup>2</sup>Johnson Plateau

<sup>3</sup>Lostwood National Wildlife Refuge - Lostwood

<sup>4</sup>Fort Peck Indian Reservation

<sup>5</sup>Class I standards are not yet in force at the Fort Peck Indian Reservation but are under application.

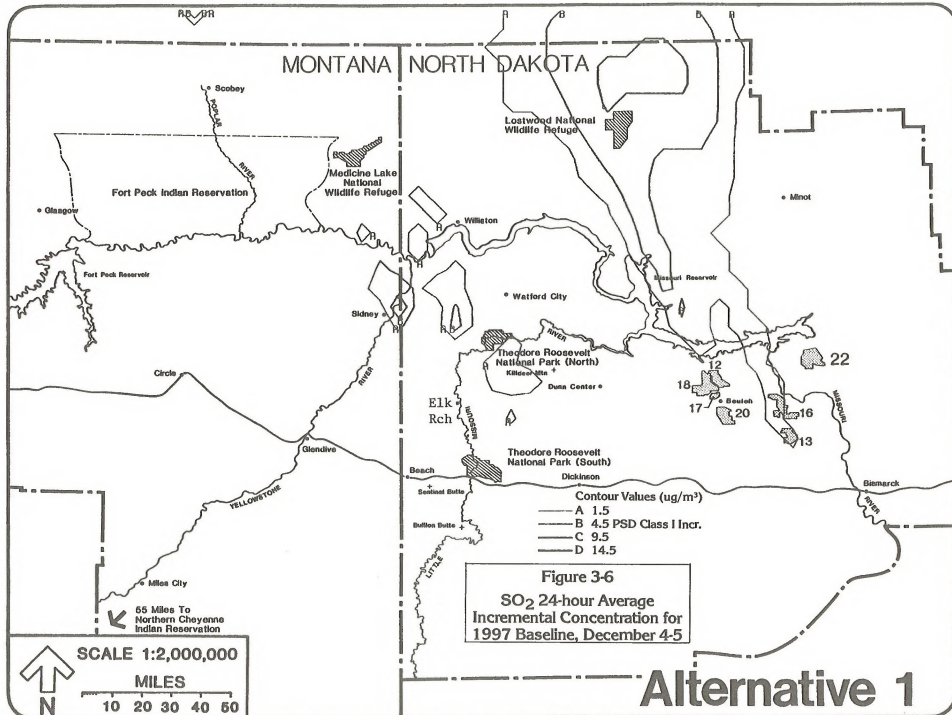
Cumulative 24-hour SO<sub>2</sub> increments predicted by MESOPUFF at the TRNP North Unit are higher for the December 3-5 episode than for the July 4-6 episode. Modeling results for these episodes indicate that allowable 24-hour SO<sub>2</sub> increments are exceeded by cumulative impacts from 1997 baseline sources and those of Alternatives 4, 5 and 6. The predicted highest cumulative increment for these alternatives is 6.44 ug/m<sup>3</sup>, with 2.72 ug/m<sup>3</sup> contributed by baseline sources. Figure 3-6 depicts the 24-hour average sulfur dioxide increments for 1997 baseline sources for the second day of the December episode. Cumulative increments for Alternative 5 for the same modeling period are contoured in Figure 3-7. From these figures, it can be seen that emissions from proposed mining tracts located south-southeast of the TRNP North Unit (i.e. Zenith, Dunn Center and Werner tracts) are the principal source of concentrations which exceed the allowed limit.

In addition to the potential violation of the total allowed SO<sub>2</sub> increment at TRNP-N, modeling results for the July 3-5 episode also indicate that the allowable 3-hour SO<sub>2</sub> increment (25 ug/m<sup>3</sup>) will be exceeded by cumulative emissions from Alternatives 3, 4, 5 and 6 plus those from 1997 baseline sources. The cumulative increment for these alternatives is predicted to be 35 ug/m<sup>3</sup>, with roughly half contributed by the baseline sources.

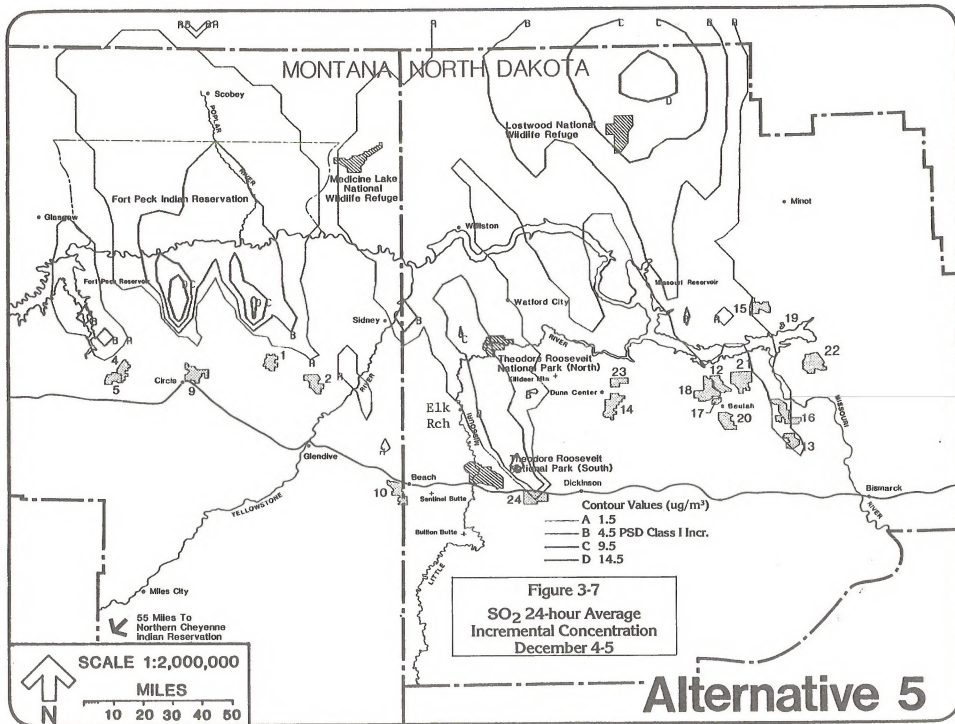
Predicted TSP cumulative 24-hour increments at the TRNP-North Unit for all leasing alternatives are below the allowable increment of 10 ug/m<sup>3</sup>. The highest cumulative increment of 7.4 ug/m<sup>3</sup> is obtained for Alternatives 3 through 6. Incremental impacts from Alternative 2 are insignificant.

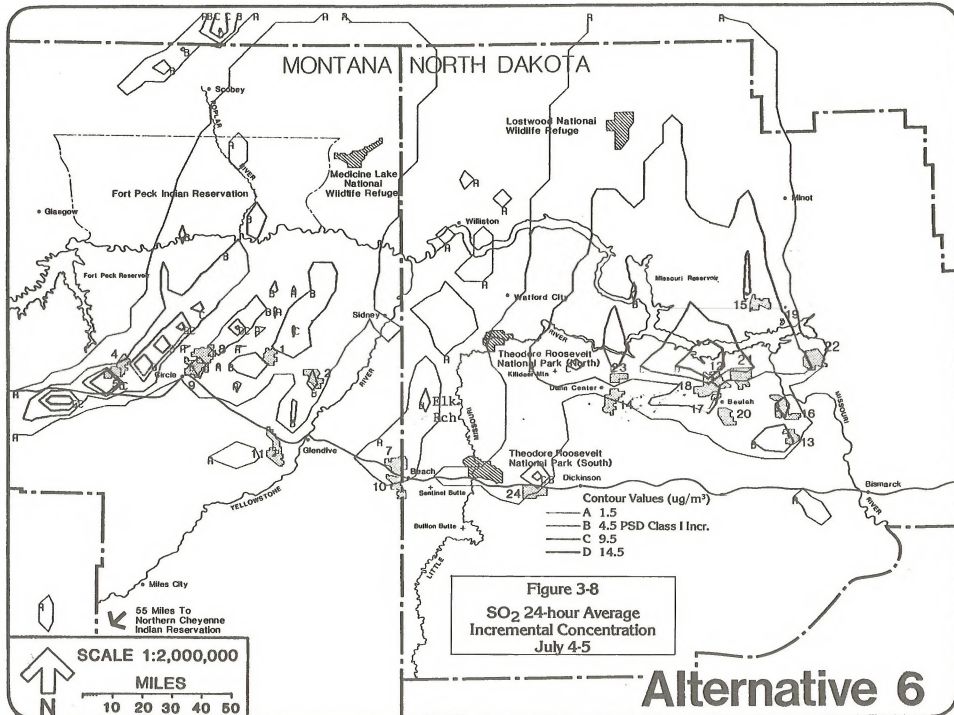
Only the July 3-5 episode results in modeled 24-hour average SO<sub>2</sub> increments in excess of allowed limits at the South Unit of TRNP. Johnson Plateau, located within the Park, was selected as the representative receptor site. The increment from baseline sources is small (0.5 ug/m<sup>3</sup>), while the increment from sources at the Zenith tract (5.71 ug/m<sup>3</sup>) for Alternatives 4 through 6 marginally exceeds the allowed increment. Figure 3-8 shows the isopleths of cumulative 24-hour SO<sub>2</sub> increments obtained for Alternative 6 at the end of the first day of the July 4-6 episode. This figure, although not displaying highest impacts, does show that impacts at TRNP-South are caused primarily by the proposed Zenith tract, which is located close to the park. Cumulative 3-hour SO<sub>2</sub> increments are predicted to be 21.4 ug/m<sup>3</sup> and 18.8 ug/m<sup>3</sup>, for the July 3-5 and July 4-6 episodes, respectively. These levels represent approximately 80 percent of the allowable increment.











The highest predicted TSP increment at TRNP-South is 6.5 ug/m<sup>3</sup> for Alternatives 4 through 6. Figure 3-9 shows the isopleths of 24-hour cumulative TSP increments from Alternative 4 for the first day of the July 4-6 episode. It can be seen that impacts from fugitive mining emissions are close to the sources. Only insignificant increment impacts are predicted for Alternatives 2 and 3 for all of the modeled episodes. It should be noted that the modeled cases may not represent the maximum worst-case impacts at the South Unit of TRNP. Previous modeling studies conducted by the NDSHDH using different meteorological episodes indicate that both the 3-hour and 24-hour sulfur dioxide increments at TRNP-S will be consumed by existing and pending PSD sources.

All modeled SO<sub>2</sub> and TSP increments for the Elkhorn Ranch are within allowable limits.

Cumulative SO<sub>2</sub> and TSP increments at Medicine Lake Wildlife Refuge are well below allowed limits for all leasing alternatives. The total 24-hour SO<sub>2</sub> increment for Alternative 6 is 3.75 ug/m<sup>3</sup>. The modeled receptor point was located at the town of Homestead, near the southwest edge of this Class I area.

The July 4-6 and December 3-5 episodes result in total 24-hour SO<sub>2</sub> increments in excess of the 5 ug/m<sup>3</sup> federal and state limits at Lostwood National Wildlife Refuge. The town of Lostwood was selected as the representative receptor for this Class I area. The 1997 baseline increment under December 3-5 meteorology (7.5 ug/m<sup>3</sup>) exceeds the allowed limits and results in a significant concentration of 11.8 ug/m<sup>3</sup> when project tracts of Alternatives 3 through 6 are included. Figure 3-6 indicates the extent of impacts from baseline sources. These impacts are caused by prevailing south-southeast winds which transport plumes from existing and pending PSD sources towards this Class I area. Total concentration increments for these alternatives (approximately 5.6 ug/m<sup>3</sup>) during July 4-6 meteorology only moderately exceed the allowed increments.

Modeled 24-hour average SO<sub>2</sub> concentrations for Alternative 6 during December 3-5 meteorology exceed the allowed PSD Class I increment over a large portion of the Fort Peck Indian Reservation, as shown in Figure 3-10. Although the reservation is not yet designated as a Class I area, such designation is under current consideration. Incremental SO<sub>2</sub> concentrations from Alternative 6 approach 14.5 ug/m<sup>3</sup> in the southwest section of the reservation. This is almost three times the allowable Class I increment. Alternative 5 would also cause exceedance over a large area of the reservation, as may be seen in Figure 3-5.

All modeled increments for the Northern Cheyenne Indian Reservation Class I area are well below allowed limits.

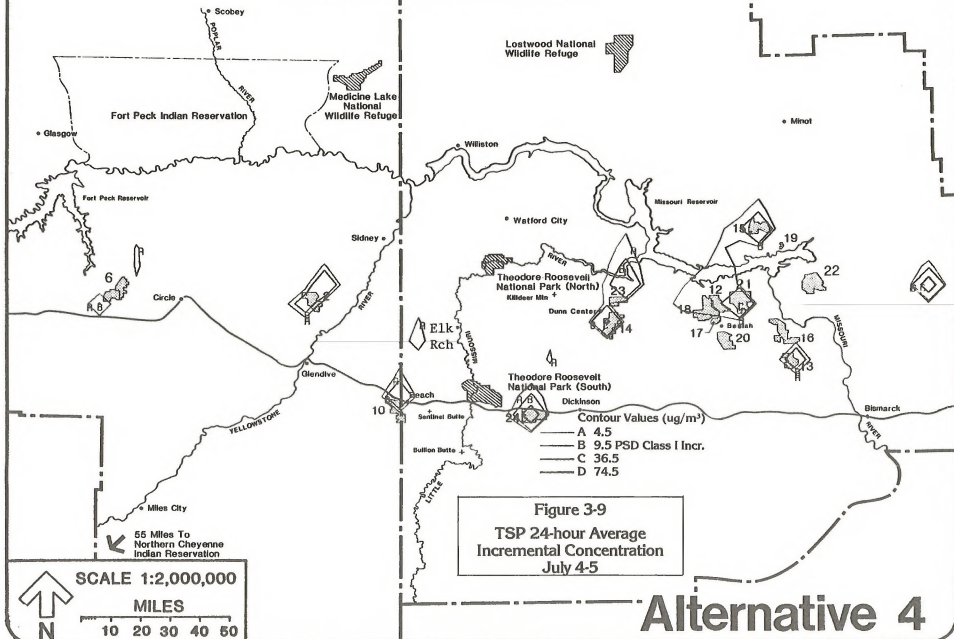
Modeling of annual-average SO<sub>2</sub> and TSP increments was conducted with the climatological dispersion model CDMQC. Modeling results indicate that the allowed sulfur dioxide increment (2 ug/m<sup>3</sup>) is exceeded at the North Unit of Theodore Roosevelt National Park but at no other Class I area. The spatial extent of levels in excess of 2 ug/m<sup>3</sup> is shown in Figure 3-11 for Alternative 5 emissions; it covers a large area of west-central North Dakota. It is estimated that the 1997 baseline sources consume 75 percent of the allowable increment (2 ug/m<sup>3</sup>). Incremental concentrations from Alternative 5 and 6 sources were predicted to be 0.5 and 0.66 ug/m<sup>3</sup>, respectively. Cumulative SO<sub>2</sub> increments at all other PSD Class I areas are below the limit for all leasing alternatives.

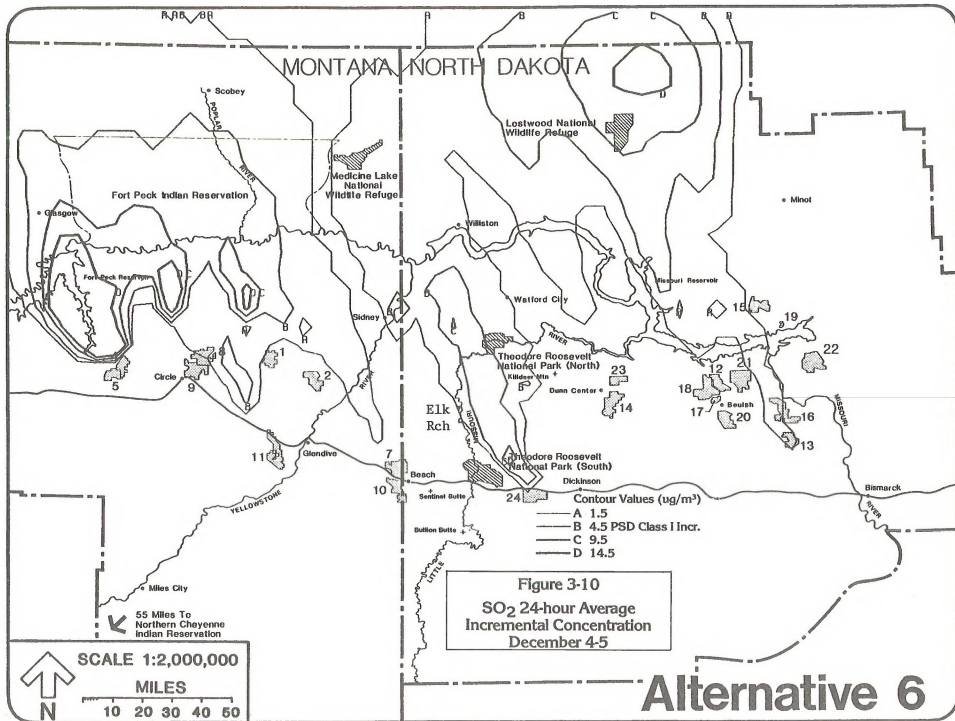
Predicted annual-average TSP increments from all sources are below the Class I allowed increments for all leasing alternatives. Figure 3-12 shows the isopleths of annual average cumulative increments for Alternative 5. As expected, the zones of impact are very close to the sources and, thus, they do not significantly impact any PSD Class I area.

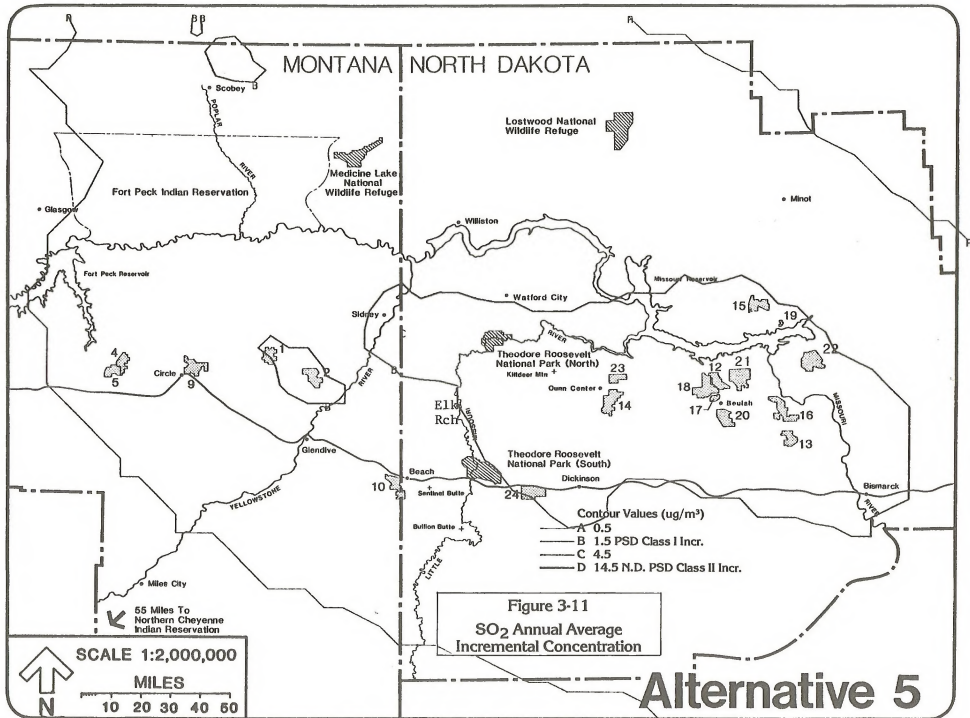
#### Incremental Pollutant Concentrations Relative to PSD Class II Standards

Aside from the PSD Class I areas described above, the Fort Union Coal Region is currently designated as PSD Class II areas. The State of North Dakota has established allowable increments for SO<sub>2</sub> and TSP for Class II areas, which are equal to or more stringent than the federal standards. However, these Class II increments are much higher than those allowed for Class I areas. For example, the allowable 24-hour SO<sub>2</sub> increment for Class II areas is nine times larger than the Class I increment (91 ug/m<sup>3</sup> versus 10 ug/m<sup>3</sup>). Thus, allowable Class II increments are generally not expected to be exceeded. However, analysis of modeling results (both short-term and annual-average) reveals that the North Dakota annual TSP increment of 15 ug/m<sup>3</sup> will be exceeded by all five leasing alternatives. Figure 3-13 shows the isopleths of cumulative annual TSP increments for Alternative 4. In this figure, the state allowable increment is exceeded near some proposed and existing project tracts (Werner, Truax and Antelope).

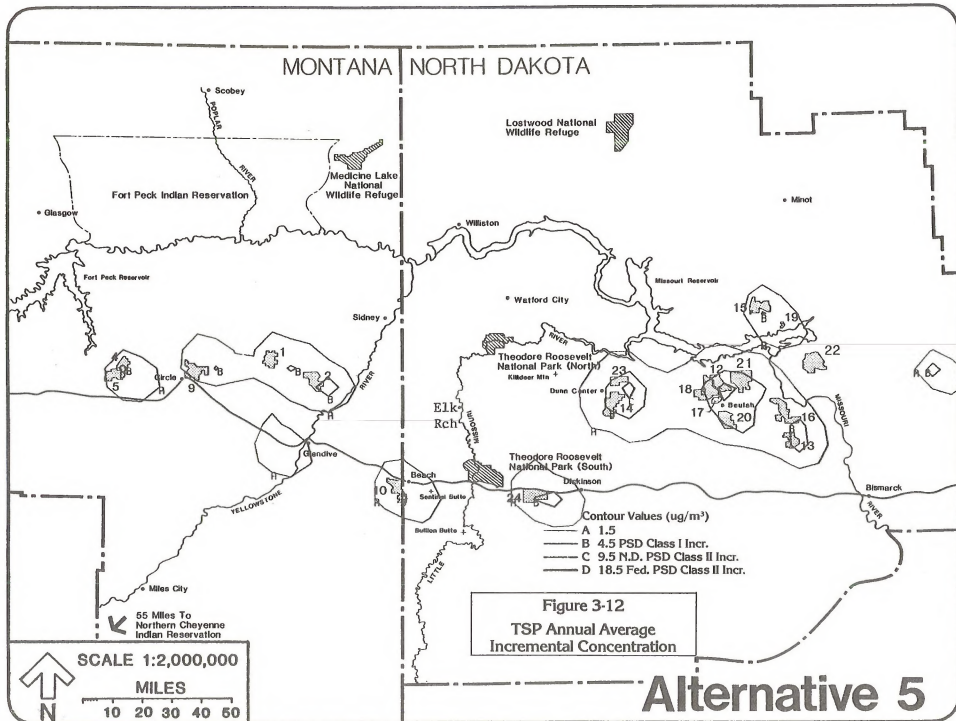
MONTANA | NORTH DAKOTA











MONTANA | NORTH DAKOTA

**Lostwood National  
Wildlife Refuge**

Medicine Lake  
National  
Wildlife Refuge

Fort Peck Indian Reservation

- Glasgow

### Fort Peck Reservoir

**Sidney**

Williamson

• Watford City

Missouri Reservoir

- Mingot



Elk  
Rch

National Park (North)  
Killedeer Mtn +

Dunn Center

Theodore Roosevelt National Park (South)

Dickson

Contour Values ( $\mu\text{g}/\text{m}^3$ )

- A 1.5

- B 4.5 PSD Class I Incr.

- C 9.5 N.D. PSD Class II Incr.

- D 18.5 Fed. PSD Class II Incr.

### 55 Miles To Northern Cheyenne Indian Reservation

**SCALE 1:2.000.000**

MILES

10 20 30 40 50

**Figure 3-13**  
**TSP Annual Average**  
**Incremental Concentration**

## Alternative 4

## REGIONAL VISIBILITY MODELING ANALYSIS

Visual air quality is a subjective value determined in part by quantifiable visual factors. The human perception of scenic vistas is affected by atmospheric quality between the observer and the scenic elements. Particle and gaseous air contaminants released from man-made sources can absorb and scatter light. This can result in a change to color, texture, line and form of an observed vista. Color and texture are the first to be degraded, followed by line and form. A local or regional haze, caused by light-scattering aerosols (airborne particles) can wash out detail in distant scenic elements. Or, a colored plume across a visual field can intrude upon subjective appreciation of a natural vista. (For further discussion of visibility phenomena and regulation, see Chapter 2.)

This section summarizes a modeling analysis of visual factors near Class I areas. It also describes a documented scale for categorizing the quantified adverse effects from proposed coal leasing upon visual air quality. The methodology and assumptions used in the analysis are presented first, followed by the quantified estimates of visual effects of BLM-proposed coal resources development. There are no standards, comparable to AAQS or PSD standards, for short-term degradation of visual air quality such as could be caused by acute air pollution episodes. A more detailed treatment of this modeling study is provided in the technical report (ECOS Management Criteria, Inc., 1982).

### Methodology and Assumptions

#### Selected Vistas

The Theodore Roosevelt National Park (TRNP) is a popular recreational facility in the Fort Union Coal Region. TRNP consists of the South Unit near Medora in Billings County, the North Unit near Watford City in McKenzie County, and the Elkhorn Ranch in Billings County, midway between the larger units. Approximately 600,000 people visited TRNP in 1979 (National Park Service, 1980). The average stay was approximately 2 hours in the North and South Units, while visitation at the Elkhorn Ranch was minimal.

The National Park Service published in the Federal Register on January 15, 1981, integral vistas associated with TRNP which are to be considered for protection from significant visibility impairment (see Table 2-2). These include two vistas originating from Johnson's Plateau and looking south toward Bullion Butte and west toward Sentinel Butte. These vistas were selected for quantified analysis for the South Unit. The Oxbow Overlook to Killedeer Mountain vista was selected for assessment for the North Unit. Data on these vistas are presented in the technical report.

#### Model Selection

There are two classes of visual effects which can be modeled: (1) plume blight (discoloration, veiled haziness or direct observation of a plume from a single emission source); and, (2) widespread regional haziness. Plume blight results from scattering or absorption of visible light from source emissions or from secondary pollutants produced from source emissions. Regional haze results from the widespread mixing of emissions from many sources with natural aerosols. Current federal regulations are focused primarily on the plume blight problem. For this regional study, however, a state-of-the-art visibility model for regional visibility effects was used to calculate visibility impairment parameters along user-specified lines of sight. The model accepts concentration fields calculated by another air quality model, such as MESOPUFF. The model was adapted from a model developed by Environmental Research and Technology (Drivas, et al., 1981) and is described in Appendix I of the technical report. The model accounts for light scattering and absorption caused by five pollutants: nitrogen dioxide ( $\text{NO}_2$ ), nitrates ( $\text{NO}_3$ ), sulfates ( $\text{SO}_4$ ), and carbonaceous and non-carbonaceous particulates. The model calculates radiative transfer parameters at four wavelengths in the visible spectrum. For each set of hourly averaged vista concentration data, the model calculates: (1) reduction of visual range; (2) sky discoloration; (3) degradation of object contrast; (4) plume contrast; and, (5) plume discoloration. Adverse impacts are determined in terms of a threshold separating "significant" from "insignificant" visual impairment of visual quality (see Appendix G for additional details).

#### Modeling Cases and Inputs

Concentrations were calculated by MESOPUFF along integral vistas using July 3-5 meteorology and emissions for the five alternative project scenarios. The MESOPUFF modeling showed that this was the most significant episode for estimating adverse visibility effects near TRNP. Modeled concentrations of TSP,  $\text{SO}_4$ , and  $\text{NO}_2$  were prepared as inputs to the visibility model. Mid-morning and mid-afternoon data were selected for visibility modeling. The cases which showed significant concentration along the selected vistas were: (1) the Oxbow-Killedeer Mountain vista during 1200-1500 CST on July 3 and 0900-1400 CST on July 5; and (2) the Johnson Plateau-Sentinel Butte vista during 0900-1400 CST on July 5.

Pollutant concentrations along the Johnson's Plateau-Bullion Butte vista were calculated but found to be insignificant, hence no significant impacts on visibility are predicted for this vista for any of the project alternatives. The model also requires an estimate of background visual range. The value used (120 km; Walther, et al., 1981) was developed by the University of Nevada during field measurements in 1979-1980 at TRNP

South Unit, for the EPA. This value is consistent with values obtainable using the EPA Workbook for Estimating Visibility Impairment (EPA, 1980).

## Modeling Results and Potential Adverse Impacts

Modeling was conducted in two phases for each vista and assessment hour: degradation of visual parameters from 1975 and 1997 baseline sources; and added degradation from inclusion of emissions from each project alternative. The three significant factors for assessing the selected vistas are reduction of visual range, degradation of contrast of views elements, and atmospheric discoloration.

### Oxbow Overlook-Killdeer Mountain Vista

Baseline emissions near the North Unit of TRNP resulted in a modeled reduction of visual range varying from 0.1 percent (at 1200 on July 3) to 26 percent (at 0900 on July 4). The corresponding reductions with the project alternatives included were: 2-30 percent for Alternative 2; 2-44 percent for Alternative 4; and 2-45 percent for Alternatives 3, 5 and 6. The 26 percent reduction in visibility due to baseline emissions translates to a drop in visual range from 120 km to 89 km. The range drops to as little as 66 km for Alternatives 3 through 6 during the most adverse hour modeled. The

greatest adverse effect of Alternative 2 occurs at a different hour—1300 on July 4—from that for the other modeled cases.

The above data and those for contrast degradation and atmospheric discoloration are summarized in Table 3-6. A more extensive breakdown of the data can be found in the technical report. Degradation of contrast by baseline emission sources is as great as 64 percent. Contrast degradation increases from 64 to 82 percent for Alternatives 3 through 6 at the most impacted hours.

Atmospheric discoloration can be characterized by the reduction of blue light with respect to red light, expressed as a ratio (a ratio of 1.0 is interpreted as an equal attenuation of both colors during passage along the line of sight and represents no discoloration, while a ratio of zero represents total attenuation of the blue component). Baseline sources produce a modification of the blue-to-red ratio by as much as 0.737. Alternative 2 results in only a slight further degradation of these parameters. But atmospheric discoloration significantly increases, as represented by a blue-to-red ratio of 0.68, for the other mining alternatives. Data in Table 3-6 indicate potentially significant adverse visual impacts from both baseline emissions and from project Alternatives 3 through 6 at the North Unit of TRNP.

TABLE 3-6  
Adverse Effects of Emissions on the Oxbow-Killdeer Mountain Vista

Parameter	Visibility Degradation*			Conservative Adverse Thresholds
	Baseline	Alt. 2	Alt. 3-6	
Least Impact:				
Visual Range Reduction				5% or more
1200 CST on 7-2	0.1%	1.7%	1.7%	
Contrast Degradation				10% or more
1200 CST on 7-2	0.4%	5.4%	5.4%	
Atmos. Discoloration				9.0 or less
1200 CST on 7-2	0.995	0.994	9.994	
Greatest Impact:				
Visual Range Reduction				5% or more
0900 CST on 7-3	<u>26.3%</u>		<u>44-45%</u>	
1300 CST on 7-3		29.7%		
Contrast Degradation				10% or more
0900 CST on 7-3	<u>64.4%</u>		<u>82%</u>	
1300 CST on 7-3		66.1%		
Atmos. Discoloration				0.9 or less
1400 CST on 7-2	<u>0.737</u>	0.771		
0900 CST on 7-3			<u>0.68</u>	

\*Significant adverse impacts, as defined by the listed threshold values, are underlined in the table. Those for Alternative 2 result solely from baseline emissions.

### Johnson Plateau-Sentinel Butte Vista

Table 3-7 summarizes the modeling results for the assessment of adverse impacts at the South Unit of TRNP. There are no significant adverse impacts from Alternatives 2 and 3, nor from the baseline emissions. Adverse effects upon visual range, atmospheric contrast and discoloration are approximately the same for the other alternatives which are tabulated. Data in Table 3-5 indicate potentially significant adverse visual impacts from Alternatives 4 through 6 at the South Unit of TRNP.

## INDIRECT OR SECONDARY CONSEQUENCES

### Acid Precipitation

The effect of the project in relation to acid precipitation is an area of particular concern due to the potential long

range transport and long term effects of acid precipitation. The major components of acid rain are sulfuric and nitric acids which result from a transformation of sulfur dioxide and oxides of nitrogen in the atmosphere. The effects of these acids can range from devastating to beneficial and have been studied for the most part in northern Europe, eastern Canada and the northeastern U.S., where the acidity of precipitation has been on the rise since the early 1900's due to increased emissions of acid-forming sulfur and nitrogen compounds. This acidic precipitation can acidify soils and natural waters causing mineral leaching and damage to many aspects of the biosphere. In addition, acid precipitation has been linked with accelerated corrosion of metals, painted surfaces, wood, masonry, and statuary. (For further discussion of existing knowledge of acid precipitation, see discussion in Chapter 2, Affected Environment.)

TABLE 3-7  
Adverse Effects of Emissions on the Johnson Plateau-Sentinel Butte Vista

Parameter	Visibility Degradation*		Conservative Adverse Thresholds
	Baseline	Alternatives 2-6	
Least Impact:			
Visual Range Reduction			5% or more
0900 CST	0.66%		
1400 CST		2.65%	
Contrast Degradation			10% or more
0900 CST	2.10%		
1400 CST		8.75%	
Atmos. Discoloration			0.9 or less
0900 & 1400 CST	0.983		
1400 CST		0.972	
Greatest Impact:			
Visual Range Reduction			5% or more
1100 CST	1.03%	<u>18.96%</u>	
Contrast Degradation			10% or more
1000 CST	3.48%		
1100 CST		<u>43-47%</u>	
Atmos. Discoloration			0.9 or less
1100 CST	0.976		
1000 CST		0.87	

\*Adverse impacts, as defined by the listed threshold values, are underlined in the table. All modeled cases shown here occurred during the July 5 episode.



Although neither definition nor effects of acid precipitation have been established in the Fort Union Coal Region, a project was recently begun to monitor the chemical composition of precipitation in North Dakota by the State Department of Health. Precipitation has been collected at Dunn Center and Woodworth in order to obtain representative data from western and eastern areas of the state. Analysis of samples collected between April and December 1981 indicates mean pH values somewhat lower than had previously been estimated or extrapolated based on data from locations outside the state (NDS DH, 1982). Mean, median and extreme values are provided in Table 3-8.

**TABLE 3-8**  
**Acidity of Precipitation in North Dakota**  
**April — December 1981**  
**Acidity expressed in pH units\***

Statistic	Dunn Center	Woodworth
Mean	4.87	4.98
Median	4.77	5.07
Maximum	6.22	6.54
Minimum	3.98	4.33

\*The pH of pure water at equilibrium with atmospheric carbon dioxide at standard temperature and pressure is generally accepted to be 5.65.

Source: NDS DH, 1982.

The properties of soil affect its capacity to withstand the deleterious effects of acid precipitation. Within North Dakota, many areas, including Mercer, McHenry, Divide, and other counties east of the Fort Union Coal Region, contain soils that are uncultivated, sandy, loamy or noncalcareous sandy. These soil types would be particularly sensitive to increased acidity (NDS DH, 1982).

In the western portion of the Fort Union Coal Region, including most of the Montana portion, the soils would be much less affected by acid precipitation, having considerable capacity to buffer acidity as well as being generally thick in depth. Thinness of soil cover is one of the important factors in the acid rain problem in northeastern U.S., contributing to the sensitivity of that region to acid precipitation. The soils in the western part of the Fort Union area, furthermore, tend to be alkaline, hence have greater capacity to neutralize acidity than non-alkaline soils, as in northeastern U.S. Airborne soil dust is, in fact, believed to play some part in neutralizing precipitation acidity, particularly in the summer.

Surface waters within North Dakota and presumably Montana typically exhibit a buffering capacity which is not likely to be exceeded through inputs of atmospheric acids in the near future. However, if the mean pH values as measured by the Department of Health are indicative of a trend toward increasing acidity, the buffering capacity will eventually be consumed and pH levels may decrease to the point that would indicate serious effects. It is also quite possible that during periods of snowmelt, sufficiently acidic runoff could exceed the buffering capacity of aquatic systems (NDS DH, 1982).

Two acid deposition monitoring sites have been established in Montana, at Fort Peck and at Glacier, but no data or conclusions from these have yet been published.

Based on current knowledge, there can be little doubt that emissions of sulfur dioxide and nitrogen oxides by project sources at the rates shown in Table 3-1 will contribute acidity to atmospheric deposition. Whether the increase will be significant and where it may show up geographically, however, cannot be readily determined by current scientific knowledge.

Acidic aerosol concentrations produced through conversion of sulfur and nitrogen oxides emissions build up over a period of time. In the modeling study, the conversion was linear over time for episodes lasting up to 48 hours of pollutant release and dispersion. Pollutant residence times in the Fort Union Coal Region probably range up to four days. Consequently, the design of the modeling program could not determine maximum possible sulfate concentration levels from which acid deposition rates can be inferred.

Hourly sulfate concentration levels along integral vistas were computed for the visibility study. The highest concentrations from four vistas for the five alternatives were 4.32  $\mu\text{g}/\text{m}^3$  for Alternatives 3 through 6. This level is considerably less than the highest three-hour average sulfur dioxide concentration (35  $\mu\text{g}/\text{m}^3$  in Table 3-3). Detailed printouts of modeled  $\text{SO}_2$  and  $\text{SO}_4$  concentrations in each modeling cell showed the partial conversion of sulfur dioxide to sulfates within the modeling period. This modeled conversion rate should be accurate to within a factor of two. Since modeled  $\text{SO}_2$  could be low by as much as a factor of two, as well, the modeled  $\text{SO}_4$  concentration could be low by as much as a factor of four. Not all sulfate produced in the atmosphere converts to sulfuric acid; some sulfate will be associated with other positive ions besides hydrogen. In summary, the modeling study does not point to a significant production of acidic rain in the Fort Union Coal Region.

Some acid pollutants will probably be carried into areas outside of the Fort Union Coal Region; significant amounts may also be transported to distant parts of the continent or the globe. For these as well as other rea-



sons, the environmental consequences of acid pollution cannot easily be predicted. However, based on the studies by the North Dakota State Department of Health, which indicate widespread incidence of significantly acid precipitation, and in view of regional terrestrial and aquatic systems which would not withstand long-term trends of increased acidity, impacts in the region are indeed possible, and monitoring studies should be continued and expanded, particularly in Montana.

## Trace Pollutants

### Organic Compounds

Coal conversion processes which produce synthetic liquid or gaseous fuels result in a variety of air pollutant emissions. One category of pollutants, as yet unregulated, are organic compounds, large numbers of which may be in the gaseous, liquid, tar and solid streams of coal conversion activities via combustion sources and leaks in storage tanks, processing units and transfer operations. It has been estimated that only a small percentage of such compounds have been identified, and research concerning their potential effects is considered to be in the early development stages (National Wildlife Federation, 1981; EPA, 1981).

Several groups of organic compounds have been identified among potential emissions; these include aliphatic, alicyclic, aromatic, and polycyclic aromatic hydrocarbons, and phenolic materials. Some compounds of these classes, particularly the polycyclic aromatic hydrocarbons, are considered to be carcinogenic. In addition to the carcinogenic risk, some of these organic compounds have been linked to or are known to induce behavioral, neuro-toxicological, skin, blood and reproductive system disorders (National Wildlife Federation, 1981). Specific known compounds and potential effects are listed in Table 3-9.

Although the potential health risks are considerable, available scientific data have not identified minimum ambient levels above which deleterious effects to humans and/or the biosphere might be expected. Nor are data yet known by which emission rates and ambient concentrations may be predicted for a proposed coal liquefaction or gasification plant. EPA is aware of the need for research studies and analyses to determine possible mutagenic or other health effects associated with synthetic fuel developments and has such research currently under way (EPA, 1981).

Due to the significant size of gasification and liquefaction facilities associated with development alternatives of the Fort Union Coal Region, this is an area of potential concern and should be more critically evaluated as more intensive studies are completed, and as specific coal conversion projects are proposed.

TABLE 3-9

### Health Effects Associated with Emissions of Organic Compounds from Synfuel Developments

Compound	Health Effect
Alicyclic Hydrocarbons	
Alkanes	Skin and nervous system
Dodecane	Cancer promoter
Aromatic Hydrocarbons	
Benzene	Cancer, chromosomal damage, aplastic anemia, nervous system impairment
Substituted benzenes (toluene, xylene, etc.)	Skin and eye irritation, nervous and reproductive system impairment
Phenolics	
Phenol, cresols	Cancer promoter, skin and eye irritant, chromosomal, liver and kidney damage, nervous system impairment
Polycyclic Aromatic Hydrocarbons	
Benzo(a)pyrene	Cancer

Source: National Wildlife Federation 1981.

### Metals and Other Particulates

Although the major constituents of coal are carbon-containing compounds, there are minor or trace quantities of many other elements and compounds in coal. When coal is burned, these trace chemical species are emitted from the combustion chamber along with the combustion products in the form of either vaporized compounds or particulate solids. In modern facilities equipped with efficient emission control devices required by air quality regulations, a very high percentage of particulate emissions are captured and not emitted into the environment. However, large scale operations, such as envisioned for the Fort Union coal leasing program, will result in significant quantities of particulate emissions, as shown in Table 3-1, with consequent dispersion into the atmosphere of the trace elements in the coal. The question must therefore be considered, how will the dispersion of these elements affect the environment? The importance of the question is underscored by the fact that many of the trace elements in coal are toxic to life forms.

To provide information leading to answers to this question, the North Dakota State Department of Health recently initiated a series of studies on the subject. They found that lignite coals of the Fort Union Coal Region contain 15 trace elements in the concentrations shown in Table 3-10. Most of these elements are toxic to some degree in some circumstances, while some of them are

beneficial to life processes under certain circumstances. The North Dakota study of the deposition of these elements in the soils near coal-fired electric generating stations indicated that rates of accumulation of the elements in the soils are relatively minor as compared with the quantities already present in the soils. This information led to the conclusion that deposition of trace elements from the development of energy resources in west-central North Dakota would not be expected to cause adverse effects on ecosystems during the short term period encompassed by their phase one study (one year). However, no conclusions could be reached regarding longer term effects. It was therefore recommended, and planned, to continue the studies. Further details of the phase one study may be found in the West-Central North Dakota Regional Environmental Impact Study on Energy Development and associated documents (BLM, 1978c). The same conclusions and caveats apply to the Fort Union Regional EIS.

#### Radioactive Elements

A sub-category of trace elements in coal which are of special concern is radioactive elements. Although

these elements are normally present in coal in extremely minute amounts, their presence is of concern because of the severe health hazard of radioactivity. Uranium and other naturally occurring radionuclides are found in all coals as they are in all parts of the lithosphere. The uranium content of representative Fort Union coals is shown in Table 3-10.

There is presently little information on the radioactive material content of Fort Union lignite coal, other than uranium concentrations. The EPA has examined the question of radioactive emissions from coal combustion in a document entitled, "Potential Radioactive Pollutants From Expanded Energy Programs" (EPA-600/7-77-082, August 1977). Appendix D contains a projection of emissions of radioactive material from five coal types in microcuries per day (microcuries, a unit of radioactivity describing the rate of decay of radioactive material. One microcurie equals  $3.7 \times 10^4$  nuclear transformations per second). This projection involved a number of assumptions concerning the amount and distribution of radioactive material in the emission of particulate matter from a 1,000 megawatt power plant employing a 99.5% particulate collection efficiency.

TABLE 3-10  
Tract Elements in Lignite Coal (Micrograms Per Gram)

Element	NDS DH Study (1977)			Older Literature Average
	Min.	Max.	Arithmetic Mean	
Arsenic	< 0.54	18.0	2.07	5.0
Beryllium	< 0.10	4.3	0.75	0.1 — 4.0
Cadmium	< 0.10	0.27	0.13	0.0 — 0.53
Chromium	< 0.10	13.0	1.29	4.0
Copper	0.53	7.7	2.88	< 1.0 — 40.
Fluoride <sup>1</sup>	7.4	25.0	5.53	25. — 50.
Lead	< 0.10	0.51	0.26	0.5 — 7.0
Mercury	< 0.02	0.28	( <sup>2</sup> )	< 0.2
Molybdenum	0.64	6.4	1.63	< 1.0 — 17.0
Nickel	0.12	5.8	0.93	1.3 — 40
Selenium	< 0.18	0.58	0.30	0.4 — 8.0
Uranium	< 0.10	1.4	0.47	
Vanadium	< 0.60	19.0	2.69	0.2 — 25.0
Zinc	0.30	37.0	2.56	2.9
Sulfur <sup>2</sup>	0.37%	2.29 %	0.72%	< 0.7% — 1.5%

<sup>1</sup>As total fluoride.

<sup>2</sup>As total sulfur, % weight.

<sup>3</sup>30% of samples less than detectable limit, resulting in arithmetic mean which would fall below 0.02.

<sup>4</sup>Composite from literature search with averages from existing lignite coal data.

Source: North Dakota State Department of Health, 1977.

The example shown for the Powder River coal type corresponds most closely with the Fort Union lignite coals. The Powder River Wyoming subbituminous coal used in this projection was 8,200 Btu/lb, 6% ash, with uranium and thorium concentrations of 0.7 and 1.9 parts per million, respectively. This compares to Fort Union lignite with 6,800 to 7,000 Btu/lb, 6.2% to 8% ash, with uranium and thorium concentrations of 0.83 and 0.77 parts per million, respectively (D.M. Baria, A Survey of Trace Elements in North Dakota Lignite and Effluent Streams from Combustion and Gasification Facilities). In contrast, the subbituminous coal from the Navajo Reservation of New Mexico, in this projection, had characteristics of 8,500 Btu/lb, 25% ash, with uranium and thorium concentrations of 1.2 and 4.8 parts per million, respectively.

Releases of radon gas (radon 222 and radon 220) from these five plants were also compared in Table 3-11 with the assumption that all of the radon in the coal exists in the stack without any removal or capture in the pollution control devices of the combustion facility. This is a maximum, worst-case condition, since some radon may be caught in the sulfur dioxide scrubbers and because radon 220 has a comparatively short radiological half-life of 54.5 seconds. (Radioactive half-life is the time it takes a given radioactive material to decay to half its original radioactivity.) Some radon 220 could be expected to decay to a particulate with subsequent attachment to ash particulate and be captured in the particulate pollution control device.

TABLE 3-11  
Release of Radon Isotopes  
from a 1,000-MW Power Plant

Coal	Radon Release ( $\mu\text{Ci/day}$ ) <sup>1</sup>	
	RN-222	Rn-220
Appalachia (bituminous)	3,140	1,870
Illinois-W. Kentucky	7,050	2,220
Powder River Wyoming (subbituminous)	2,980	2,720
Navajo Reservation, New Mexico (subbituminous)	5,000	6,500
Kaiparowits Plateau, Utah (bituminous)	2,260	1,670

Source: U.S. Environmental Protection Agency Potential Radioactive Pollutants Resulting From Expanded Energy Development (EPA-600/7-77-082) August 1977.

<sup>1</sup> $\mu\text{Ci/day}$  is the abbreviation for microcuries per day.

Given the similar characteristic (previously described) of the Powder River subbituminous coal and Fort Union lignite coal, the projected radioactivity emissions from burning of the Powder River coal in a 1,000 megawatt power plant would approximate the burning of lignite coal in a Fort Union 880 megawatt power plant. A coal gasification plant would have similar particulate radioactivity; however, the radon component would probably be transferred to the product synthetic natural gas. The gas loops in a gasification plant are, for the most part, closed.

The impact of radioactive emissions from Fort Union coal-based energy development in western North Dakota was analyzed by the North Dakota State Department of Health and reported in the West-Central North Dakota Regional EIS on Energy Development (1978). It was concluded that the total radioactivity released to the atmosphere from energy conversion projects would be lower than naturally occurring radioactivity, and hence that radioactive impacts of energy development in that area would be very low.

While the total rate of coal conversion projected for the entire Fort Union Region will be greater than that occurring in the west-central North Dakota area, this latter area will be the area of greatest concentration of energy conversion within the Fort Union Coal Region. Therefore, if radioactive impacts are very low here, it can be concluded that they will be very low throughout the Fort Union Coal Region.

## Secondary Impacts Associated with Population and Economic Growth

Development of coal resources in western North Dakota and eastern Montana, as elsewhere in the sparsely settled western United States, is expected to bring about increased population in the region as workers and their families move into the area in response to increased employment opportunities. As population and the level of economic activity in the region increase, so too will the number of vehicles and vehicle miles traveled (VMT). This will result in increased vehicular emissions of hydrocarbons, carbon monoxide and nitrogen oxides. These increased emissions constitute secondary impacts on air quality.

Secondary air quality impacts are evaluated for the year 1997 for the North Dakota counties and for 2000 in the Montana portion of the region. Although population is expected to peak somewhat earlier as construction activity reaches its maximum, these later years were selected for analysis on the premise that the effect of vehicle emissions on ambient air quality is expected to be greater once the facilities included in each of the alternatives become operational and are themselves discharging emissions to the atmosphere.

Population projections derived for each county in the study area under each alternative (Appendix H) were translated into estimates of vehicle miles traveled (VMT), based on historical patterns of vehicle ownership in Montana and North Dakota and average miles traveled annually per vehicle. Calculation of the volume of emissions of each of the major pollutants—hydrocarbons, carbon monoxide and nitrogen oxides—are based on vehicle miles traveled and estimates of future vehicular emissions developed by the U.S. EPA. Emission factors for the period 1997-2000 are estimated to be 2.6 grams/mile of hydrocarbons, 22.1 grams/mile for carbon monoxide and 1.9 grams/mile for nitrogen oxides (U.S. EPA, 1978). The calculated vehicular emissions are given in Appendix I.

Alternative 1 represents the baseline conditions or those levels of vehicular emissions expected to prevail in the region in the absence of further coal development on government-owned lands. As such, it provides a standard of comparison to assess the air quality impacts associated with the various alternatives.

Burleigh and Ward counties in North Dakota are expected to have the highest levels by far of each of the major pollutants under Alternative 1 (Appendix I). This, of course, is primarily a reflection of the level of population expected to be in these counties even in the absence of additional coal development. Morton and Stark are the other two counties in North Dakota with relatively high levels of emissions. In Montana, Richland and Custer counties are expected to experience the greatest loadings of vehicular emissions under baseline conditions; the amount of emissions in these counties, however, is less than one-sixth that expected in Burleigh and Ward.

The counties that would experience the greatest secondary impact under Alternative 2 are Golden Valley and Dunn in North Dakota and Wibaux in Montana. Vehicular emissions would increase by about 144 percent over baseline conditions in Golden Valley County and by nearly 75 percent in Dunn. Expected emissions in Wibaux County are projected to increase by nearly two-thirds under this alternative. Mercer County, North Dakota and Dawson County, Montana, are the only other counties in which total emissions are expected to increase by about 10 percent.

The expected pattern of secondary air quality impacts under Alternative 3 is quite similar to that just described for Alternative 2. Golden Valley and Dunn counties again incur the largest increase in vehicular emissions, with emissions in the former expected to increase by 144 percent, approximately the same as in Alternative 2. Emissions in Dunn County would increase by nearly 120 percent over the baseline, roughly half again as large as the expected change in Alternative 2. Wibaux County again would experience an increase of about 64 percent above baseline conditions. Expected emissions in both Mercer and Dawson Counties would

increase by about 22 percent, a somewhat greater increase than experienced under Alternative 2.

If the development pattern described in Alternative 5 were adopted, Golden Valley and Dunn counties again would experience the largest absolute and relative increases in vehicular emissions with projected emissions increasing by 146 percent in Golden Valley and 116 percent in Dunn. Expected emissions in Wibaux County would increase by 64 percent, roughly the same change as under the previous two alternatives. Vehicular emissions are expected to increase by 22 percent in Mercer County and by 14 percent in Dawson.

Two additional counties—Stark County, North Dakota, and Garfield County, Montana—would incur greater impacts under this alternative than under the previous two. Projected emissions in the former would increase by more than 17 percent, while in the latter, emissions are expected to increase by nearly 7 percent.

Virtually the same pattern and magnitude of changes in vehicular emissions described for Alternative 4 is projected to occur under Alternative 5. Golden Valley, Dunn and Wibaux counties again experience the largest relative changes in emissions, while Mercer, Stark and Garfield exhibit similar relative changes under both alternatives. The exception to this pattern is Dawson County, wherein vehicular emissions are expected to increase by 39 percent over baseline conditions, an increase of 25 percentage points compared to Alternative 4.

The projected pattern of coal development and distribution of population in Alternative 6 differs considerably from earlier development alternatives. Relatively more of the population change and population-related impacts are expected to be absorbed by the counties in Montana under this alternative. Wibaux County is expected to incur an increase in vehicular emissions of 335 percent over anticipated baseline conditions, a large relative increase engendered by the small absolute level of emissions in the baseline alternative.

This is the only alternative under which vehicular emissions in McCone County would be affected appreciably, with emissions increasing by 146 percent compared to Alternative 1. Dawson County, with an increase of 62 percent in emission levels and Carter County, with nearly 11 percent increase are the only other counties in Montana expected to experience more than minor changes in vehicular emissions. Emissions in Dunn County remain roughly the same as in the previous three alternatives (about 116 percent above the baseline), but vehicular emissions in Golden Valley County are projected to be 87 percent higher than in Alternative 1, which represents a decrease of roughly 60 percentage points compared to the other development alternatives. Mercer and Stark counties are the only other counties in North Dakota in which emissions are expected to increase by more than 10 percent.



In summary, vehicle emissions in only about a third of the counties in the region are expected to be more than moderately affected by any of the coal development scenarios. Dunn and Golden Valley counties in North Dakota exhibit the largest absolute and relative increases under nearly every alternative. Stark County also is expected to incur relatively large changes in vehicular emissions under Alternatives 4, 5 and 6. In Montana, Wibaux and Dawson counties are those most consistently affected by increased emissions. Absolute changes are generally small except for Alternative 5 (Dawson County) and Alternative 6 (Dawson, McCone and Wibaux counties).

Because of the rather extensive size of the region and the county-specific incidence of increases in vehicle emissions, comparisons of total changes in emissions among alternatives is not especially meaningful. It may be pointed out, however, that the largest relative increase in emissions is caused by Alternative 6, under which emissions throughout the region are expected to increase by 8.9 percent. Emissions under Alternative 5 would increase by 7.2 percent, while Alternatives 3 and 4 would induce changes of 6.2 and 6.4 percent respectively. Under Alternative 2, vehicle emissions would increase by only 3.7 percent over baseline conditions.

The only type of vehicular emissions in common with project emissions are nitrogen oxides. The effects of nitrogen oxides from vehicular sources added to those from project sources will increase the adverse impacts of the project on visibility, probably most noticeably in Golden Valley County and the vicinity of TRNP-South. However, the additional nitrogen oxide emissions from vehicles will not be large as a percentage of project emissions and they will be relatively disperse as opposed to point sources, and for these reasons will not likely cause  $\text{NO}_2$  concentrations to exceed or approach regulatory limits. The vehicular CO and HC emissions may cause noticeable and undesirable pollution under certain circumstances, such as in the center of the most highly populated communities during air stagnation episodes. For the same reasons as with nitrogen oxides, however, they are not likely to cause exceedance of standards.

## Effects on Water Quality

Air pollutants can indirectly affect water quality. Most pollutants emitted into the atmosphere return sooner or later as deposition on land or surface waters. Some of the pollution undoubtedly moves into the upper atmosphere where it can remain for long periods of time, until it is washed out.

Pollutants can enter surface waters directly or be transferred from land deposition by rain runoff. Pollutants can enter ground water by percolation of rainfall through the soil or from surface water reservoirs.

One means by which water quality may be affected is associated with acidity, as acidic rain water can dissolve and leach soil minerals and trace elements and transfer them to both surface and ground waters. Another means is that toxic chemicals and trace elements can enter surface water directly from pollutants in the atmosphere causing potential adverse effects on water quality.

The information necessary to quantify the effects of air pollution on water quality in the Fort Union Coal Region is not presently available. However, consideration of the foregoing discussions pertaining to acid precipitation and trace elements leads to the conclusion that indirect effects of the project on water quality resulting from air pollution will likely be insignificant.

## Effects On Weather

Large scale operation of coal mining and conversion plants has some potential for causing weather changes on a local, regional, or even global scale. Local or regional weather is likely to be influenced to some extent by the release of heat, water vapor and particulates, which can affect albedo (the fraction of incident solar radiation which is reflected), humidity, temperature and cloudiness, with resulting effects on precipitation and visibility.

Cloud and precipitation processes are sensitive to the number, size and type of particulates in the air from which a cloud grows and precipitation results. In fact, the process of formation of clouds depends upon the presence of minute particles called condensation nuclei, onto which water vapor can condense and form water droplets. In clean air, air without any solid or liquid particles, clouds would not form.

The microphysical and dynamical mechanisms leading to clouds and precipitation are extremely complex. Simply stated, an excess of very small particles may inhibit precipitation processes, additional extra large particles may enhance precipitation processes, additional ice nuclei (particles which act as centers for collecting water vapor to grow ice crystals or which, when in contact with droplets colder than freezing, cause these droplets to freeze) may enhance the precipitation process, or any combination may occur.

Natural condensation nuclei include vegetative pollens, windblown soils, sea salts, volcanic ash, and meteoritic dust. Natural ice nuclei are primarily soil particles; about 1 in 10,000 atmospheric particles is an ice nucleus. Other sources of condensation and ice nuclei are exhausts of motors, furnaces, industrial processes, and power plants. Particulate emission and conversion of gases to particles in plumes of power plants can create active condensation and ice nuclei.

A study of weather modification potential of coal-fired power plants in areas near the Fort Union Coal Region was conducted in 1976 by the University of Wyoming Department of Atmospheric Sciences. The study involved the Jim Bridger plant at Rock Springs, Wyoming, and the Colstrip Unit One Plant located at Colstrip, Montana. The Jim Bridger plant operates typically at 650 megawatts, but is capable of producing 1,000 megawatts. The Colstrip Unit One plant was operating at about 250 megawatts during the study, but is capable of operating at 360 megawatts. Both plants had electrostatic precipitators which were operating during the collection of data for the study. An aircraft equipped with instruments for measuring particles made several data gathering flights through the plumes of the two plants. The study emphasized an assessment of effects upon precipitation by particulates contained in plumes of the two plants.

The study concluded that additional condensation nuclei may cause small effects (increases or decreases) in the limited region of the plume, but the effects are probably negligible compared to natural year-to-year variations. However, the results of this limited study cannot necessarily be extrapolated to larger plants or interacting plumes of two or more plants due to the non-linear nature of emission and dispersion processes as well as precipitation processes.

On a larger—global—scale, there is current concern and scientific investigation of the possibility that humanity's increasing production of carbon dioxide through rapidly growing rates of combustion of fossil fuels, mainly coal, will begin to affect weather adversely in large portions of the world or even globally. The basis for the concern is that carbon dioxide absorbs heat from solar radiation, even though transparent to visible light, and if the average carbon dioxide content of the earth's atmosphere were to be raised substantially, it would be expected to cause a net increase in absorption and retention of incident solar radiation, which would in turn raise the average temperature of the atmosphere. Such a change in atmospheric temperature, if only by a few degrees, could have a profound impact on man and the entire environment.

At present, however, no conclusions are available—just questions, serious concerns, and a body of data beginning to be accumulated. It is too early to predict what effects may be caused by increased coal conversion on the large scale proposed for the Fort Union coal leasing project. This problem cannot, therefore, be weighed in present decisions concerning the leasing alternatives. It is rather a cloud which needs to be recognized on the horizon and which needs much further investigation in the coming decades.

## Effects of Accidents or Catastrophies

A mining accident which would result in reduced or terminated mining operations would decrease emissions and any adverse atmospheric effects. Emissions would also be reduced when an accident or natural catastrophe would put an end-use facility out of operation or would reduce operating levels. An accidental failure in emission control equipment, or negligence in maintaining such equipment, would result in emissions beyond those which were modeled. Such an increased adverse impact from failure to keep pollution control equipment in proper working order should be somewhat temporary and local in effect since it is very improbable that several end-use facilities would simultaneously suffer from such failures.

## SUMMARY

Substantial quantities of major air pollutants will be emitted into the atmosphere as a result of large scale coal mining and conversion operations. These air pollutants will cause some significant impacts on air quality in the Fort Union Region. Because air pollutants disperse over considerable distances, emissions from two or more project tracts can cause cumulative impacts. Computer modeling of emission dispersion on a regional basis has shown that cumulative impacts are expected to occur. The modeling analysis identified the types, degree, and locations of predicted impacts.

The types of impacts predicted for each alternative are summarized in Table 3-12. The table shows the results of comparing maximum ground level pollutant concentrations predicted for each alternative with established regulatory air quality standards. The standards include both federal and state ambient air quality standards and federal and state standards for prevention of significant deterioration of air quality.

Predicted pollutant concentrations which exceed standards (at any location in the region) are identified by an X mark in the table. (The table does not show the location of impacts nor the degree of impacts beyond whether a violation is predicted or not; this information is given in the discussion section.)

The modeling study predicts that all project alternatives, including the no action alternative (No. 1), will result in probable exceedance of ambient air quality standards for suspended particulate matter at some times and locations. It also predicts that some of the PSD standards for both sulfur dioxide and particulate increments will be exceeded by some or all alternatives. Significant impacts on visibility at Theodore Roosevelt National Park are also predicted for all alternatives (except No. 1). The visibility impacts do not imply violation of standards, as no regulatory standards have yet been established for visibility at the Park.



TABLE 3-12  
Summary of Adverse Impacts on Air Quality

Air Quality Standard	Alternative							
	1	2	3	3(M) <sup>1</sup>	3(W) <sup>2</sup>	4	5	6
Ambient Air Quality Standards								
Sulfur Dioxide								
1-hour maximum								
3-hour maximum								
24-hour maximum								
Annual average								
Total Suspended Particulates								
24-hour maximum	X	X	X	X	X	X	X	X
Annual average								
Nitrogen Dioxide								
1-hour maximum								
Annual average								
PSD Class I Standards								
Sulfur Dioxide								
3-hour maximum			X	X	X	X	X	X
24-hour maximum	X	X	X	X	X	X	X	X
Annual maximum						X	X	X
Total Suspended Particulates								
24-hour maximum								
Annual maximum								
PSD Class II Standards								
Sulfur Dioxide								
3-hour maximum								
24-hour maximum								
Annual maximum								
Total Suspended Particulates								
24-hour maximum								
Annual maximum	X	X	X	X	X	X	X	X
Visibility at TRNP		X	X	X	X	X	X	X

Note: An X mark indicates a predicted violation of the standard (except for visibility where an X mark indicates a significant impact).

<sup>1</sup>Meridian Exchange sub-alternative

<sup>2</sup>Woodson PRLA sub-alternative

The probability, degree and locations of air quality standards violations are lowest for Alternative 1 and increase progressively to Alternative 6, roughly paralleling the extent of coal-related operations and emissions.

The Meridian Exchange and Woodson PRLA sub-alternatives were not specifically modeled; their air quality impacts are predicted by comparison with those of the main alternatives. The air quality impacts of the Meridian Exchange sub-alternative, when considered as a variation of Alternative 3, will not be significantly different from those of Alternative 3. The Woodson PRLA sub-alternative, on the other hand, will result in more severe impacts than Alternative 3, similar to those of Alternative 5.

Emissions of sulfur and nitrogen oxides from coal conversion facilities may lead to precipitation of acids formed from these oxides in the atmosphere. Acid precipitation is an extremely complex and serious problem in some parts of the world. Based on existing but very sparse information, there is no significant evidence that acid precipitation is currently harmful in the Fort Union Coal Region. However, research being conducted by the North Dakota State Department of Health shows that acid precipitation is occurring in North Dakota, and indicates that the region should not be considered immune to possible effects, especially if long term trends toward worsening acid precipitation become established.

Vehicular air pollutant emissions resulting indirectly from energy development will add to regional air pollution, but the incremental effects of these emissions are expected to be generally minor.

Development of energy resources in the Fort Union Coal Region will result in emissions of many minor or trace pollutants, including organic compounds, metals and other particulates, and radioactive elements. Many of the organic compounds which may be emitted can cause toxic effects, but current information does not enable prediction of emission rates, ambient concentrations, or health effects of these pollutants.

The deposition of trace elements is not expected to cause adverse effects on ecosystems during the short term period (1 year) but no conclusions can be reached regarding longer term effects. Further studies would be needed to examine these long term effects.

It is expected that the total radioactivity released to the atmosphere from energy conversion projects would be lower than naturally occurring radioactivity, and that radioactive impacts of energy development in the Fort Union area would be very low.

The indirect effects from air emissions on water quality as a result of implementation of the proposed action or alternatives will likely be insignificant; however, the effects on water resources outside the Fort Union area is unknown.

Large scale operation of coal mining and conversion plants has some potential for causing weather changes on a local, regional, or even global scale. Local or regional weather is likely to be influenced to some extent but no conclusions can be drawn concerning global effects.

## APPENDIX A

### IMPORTANT POLLUTANTS IN THE FORT UNION REGION

Total Suspended Particulates (TSP) include all solid or semi-solid material found in the atmosphere. It includes all kinds of dust and smoke originating from both natural and man-made sources such as agricultural activities, automobile exhaust, power plant emissions, road sand, wind-blown dust, and coal development and mining. The health implications of TSP are the most complex and least understood of all common pollutants since the particulate mixture contains many chemical species and a variety of sizes. The main health concern is that particles in the respirable size range can be inhaled and trapped in the lungs. The chemical nature of the particulates then becomes important in terms of health effects on the lungs and the rest of the body. Less serious to health but of considerable aesthetic as well as economic importance is the fact that particulates reduce clarity and visibility in the atmosphere.

Sulfur Dioxide ( $\text{SO}_2$ ) is a colorless, pungent, irritating gas that most people can detect by smell or taste at low levels. It is emitted mainly from stationary sources that utilize fossil fuels (coal, oil, gas) such as power plants, gas sweetening plants, and oil well flares and vents. The pollutant is known to cause a loss in crop yield, rusting of metals, reduction of visibility, and irritation of eyes, nose, throat, and lungs.

Ozone ( $\text{O}_3$ ) is a highly reactive, unstable gas that also has a characteristically pungent odor most commonly identified with lightning storms or other electrical discharges. Increased levels of man-made ozone occur as a result of hydrocarbon and nitrogen oxides emissions, primarily from the combustion of fossil fuels. Hydrocarbons react with nitrogen oxides under the influence of sunlight to form ozone. This strong oxidizing agent causes wide-spread material damage and has been documented as a potential health hazard.

Typically, the highest concentrations of ozone are found 20 to 50 miles downwind of the hydrocarbon sources due to the time required for its formation.

Nitrogen Dioxide ( $\text{NO}_2$ ) is a reddish-orange-brown gas with a characteristically pungent odor. It is corrosive and a strong oxidizing agent. Nitrogen dioxide and nitric oxide ( $\text{NO}$ ) are the two principal oxides of nitro-

gen that are formed during high temperature combustion when nitrogen and oxygen are present. In the atmosphere these two oxides of nitrogen are closely involved in the photochemical oxidants.

Carbon Monoxide ( $\text{CO}$ ) is a tasteless, colorless, odorless gas in the earth's atmosphere. It occurs naturally in the air as the result of forest fires, the oxidation of methane, and other natural processes. Natural background levels, however, are insignificant compared to man-made concentrations produced primarily by automobiles. The health concern for  $\text{CO}$  centers around complications that arise when  $\text{CO}$  reacts with the hemoglobin in red blood cells. The substance formed reduces the amount of oxygen delivered to the body, increases the clotting tendency of the blood, and enhances edema formation.

Hydrogen Sulfide ( $\text{H}_2\text{S}$ ) is a highly malodorous gas with the odor of rotten eggs. It occurs naturally in natural gas, particularly in so-called sour gas such as found in many gas wells in the Fort Union Coal Region. Man-made sources include sewage treatment, paper processing, and oil refining. The pollutant can damage paint, tarnish copper, injure vegetation, produce a loss of the sense of smell, cause severe respiratory tract irritation, and in large doses, cause death.

Lead ( $\text{Pb}$ ) is a gray-blue metal. Atmospheric lead emissions generally result from ore smelters and the combustion of gasoline that contains tetraethyl lead as an anti-knock compound. Human exposure can be through inhalation or ingestion of particulates containing lead. The health implications of lead include impairment of hemoglobin production, anemia, and limited cases of encephalopathy and/or death.

Trace elements, such as the heavy metals, are found generally throughout the natural environment, usually in very minute or "trace" concentrations. There is no significant existing problem with trace element air pollutants in the Fort Union Coal Region, but extensive development of coal reserves could lead to their enrichment in the soil, through deposition of coal combustion emissions, with subsequent possible effects upon vegetation, animals, or both. These effects could be either direct or via the food chain.

## APPENDIX B

### POINT SOURCE PARTICULATE EMISSION ESTIMATES FOR 1980

#### Sources Within the Montana Portion of Fort Union Coal Region

Source	County	City	Part. Tons/Year
Montana Dakota Utilities	Richland	Sidney	132
Knife River Coal	Richland	Savage	150*
Holly Sugar	Richland	Sidney	389

#### Sources Near the Montana Portion of Fort Union Coal Region

Source	County	City	Part. Tons/Year
West Decker Coal	Bighorn	Decker	2,136*
East Decker Coal	Bighorn	Decker	1,995*
Spring Creek Coal	Bighorn	Hardin	2,001*
Westmoreland Resources	Bighorn	Hardin	1,180*
Montana Power (Corrette)	Yellowstone	Billings	989
Continental Oil Co.	Yellowstone	Billings	249
Exxon Co. USA	Yellowstone	Billings	612
Great Western Sugar	Yellowstone	Billings	114
Bighorn Calcium	Bighorn	Warren	240*
Western Energy	Rosebud	Colstrip	4,796*
Peabody Coal	Rosebud	Colstrip	1,164*
Montana Power Co. 1 & 2	Rosebud	Colstrip	887
Northern Cheyenne Forest Prod.	Rosebud	Ashland	140*

Source: Montana State Air Quality Bureau 1981

\*Fugitive emissions associated with mining and vehicle traffic are included.

### SULFUR DIOXIDE EMISSION ESTIMATES FOR 1980

#### Sources Within the Montana Portion of Fort Union Coal Region

Source	County	City	SO <sub>2</sub> Tons/Year
Montana Dakota Utilities	Richland	Sidney	2,192
Shell Oil, gas plant	Richland	Sidney	1,278
Perry Petrolane, gas plant	Richland	Sidney	867
Valley County Ind. Park	Valley	Glasgow	174
KENCO	Roosevelt	Wolf Point	

#### Sources Near the Montana Portion of Fort Union Coal Region

Source	County	City	SO <sub>2</sub> Tons/Year
Exxon Co., USA	Yellowstone	Billings	10,735
Farmer's Union CENEX	Yellowstone	Laurel	10,380
Montana Power Co. (Corrette)	Yellowstone	Billings	9,811
Continental Oil Co.	Yellowstone	Billings	3,051
Montana Sulfur	Yellowstone	Billings	2,136
Great Western Sugar	Yellowstone	Billings	711
Westmoreland Resources	Big Horn	Hardin	57*
East Decker Coal	Big Horn	Decker	46*
West Decker Coal	Big Horn	Decker	46*
Spring Creek Coal	Big Horn	Hardin	17*
American Colloid	Phillips	Malta	63
Western Energy			
Coal	Rosebud	Colstrip	46*
Peabody Coal	Rosebud	Colstrip	17*

Source: Montana State Air Quality Bureau 1981.

\*Includes tailpipe emissions from diesel powered vehicles.

# ESTIMATED EMISSIONS MAJOR STATIONARY EMISSION SOURCES WESTERN NORTH DAKOTA

## Major Natural Gas Processing Plants

Name & County	Cap. mcf/d	Start-up	Products	SO <sub>2</sub> (t/yr)	NO <sub>x</sub> (t/yr)	Part. (t/yr)	H.C. (t/yr)
Tioga Plant	67	1954	1. Natural gas	3,732	1,920	26	737
Aminoil	22 <sup>1</sup>		2. Sulfur (67)				
Williams Co.							
Little Knife	15	1978	1. Natural gas	1,085	7		
Warren Pot.	20 <sup>1</sup>						
McKenzie Co.							
Lignite Plant	6	1962	1. Natural gas	2,400			
Cities Service Burke Co.							
Red Wing Co.	3.5	1975		.1	177	2	64
True Oil McKenzie Co.							
Boxcar Butte	6	1976	1. Natural gas	1,35.4	39	4	53
Kerr McGee Corp.	2 <sup>1</sup>						
McKenzie Co.							
Cherry Creek	3.5	1979	1. Natural gas	469			
Alpar Res. Williams							
T.R.	15.2	1980	1. Natural gas	990	16.5	10	.3
Western Gas Billings Co.							
Missouri Ridge	2	1979	1. Natural gas	.0012	.46	.03	.006
Tenneco Oil Williams Co.							
Kock	30	1980	1. Natural gas	902	.4	2	23
McKenzie Co.							
Subtotal				9,713.5	2,160.4	44	877.4

## Proposed Plants

Name & County	Cap. mcf/d	Start-up	Products	SO <sub>2</sub> (t/yr)	NO <sub>x</sub> (t/yr)	Part. (t/yr)	H.C. (t/yr)
Amoco	100	—	1. Natural gas	1,090	52	6.16	1.6
Billings Co.							
Phillips	27	—	1. Natural gas	410	162	—	—
Williams Co.							
Subtotal				1,500	2.4	6.16	1.6
TOTAL				11,213.5	2,588.4	50	879

<sup>1</sup>Proposed expansion.

Source: NDSDM

# APPENDIX C

## AMBIENT AIR QUALITY STANDARDS (Federal, North Dakota, Montana)

Pollutant	Federal Primary Standard	Federal Secondary Standard	North Dakota Standard	Montana Standard
Total Suspended Particulates	75 ug/m <sup>3</sup> annual geom. mean 260 ug/m <sup>3</sup> 24-hr. average*	6 ug/m <sup>3</sup> annual geom. mean 150 ug/m <sup>3</sup> 34-hr. average*	60 ug/m <sup>3</sup> ann. geo. mean 250 ug/m <sup>3</sup> Max. 24-hr avg.*	75 ug/m <sup>3</sup> ann. avg. 200 ug/m <sup>3</sup> 24-hr avg.*
Settled Particulates (Dustfall)	None	None	15 tons/sq. mile 30 tons/sq. mile Max. 3-month arithmetic mean in residential areas Max. 3-month arithmetic mean in heavy industrial areas	10 gm/m <sup>3</sup> 30-day avg.
Sulfur Dioxide	0.03 ppm (80 ug/m <sup>3</sup> ) annual arithmetic average 0.14 ppm (365 ug/m <sup>3</sup> ) 24-hour average	05 ppm (1300 ug/m <sup>3</sup> ) 3-hour average	60 ug/m <sup>3</sup> (0.02 ppm) 260 ug/m <sup>3</sup> (0.10 ppm) 715 ug/m <sup>3</sup> (0.24 ppm) Max. Annual arithmetic mean Max. 24-hr. concentration Max. 1-hr. concentration	0.02 ppm ann. avg. 0.10 ppm 24-hr avg.* 0.50 ppm 1-hr avg.**
Reactive Sulfur	None	None	0.24 mg/100 cm <sup>2</sup> /day 0.50 mg/100 cm <sup>2</sup> /day Max. annual arithmetic mean Max. for a 1-month period	None
Suspended Sulfate	None	None	4 ug/m <sup>3</sup> 12 ug/m <sup>3</sup> Max. ann. arithmetic mean; Max. 24-hr concentration not to be exceeded over 1 percent of the time.	None
Sulfuric acid mist, sulfur trioxide or any combination thereof	None	None	4 ug/m <sup>3</sup> 12 ug/m <sup>3</sup> 30 ug/m <sup>3</sup> Max. annual arithmetic mean Max. 24-hr concentration not to be exceeded over 1 percent of the time Max. 1-hr concentration not to be exceeded over 1 percent of the time.	None
Hydrogen Sulfide	None	None	45 ug/m <sup>3</sup> (0.032 ppm) 75 ug/m <sup>3</sup> (0.054 ppm) Max. 1/2-hr concentration not to be exceeded more than twice in any 5 consecutive days. Max. 1/2-hr concentration not to be exceeded over twice a year.	0.05 ppm hourly avg.*
Carbon Monoxide	9 ppm (10 mg/m <sup>3</sup> ) 8-hr avg.* 35 ppm (40 mg/m <sup>3</sup> ) 1-hr avg.*	9 ppm (10 mg/m <sup>3</sup> ) 8-hr avg.*	10 mg/m <sup>3</sup> (9ppm) 40 mg/m <sup>3</sup> (35 ppm) Max. 3-hr concentration* Max. 1-hr concentration*	9 ppm 8-hr avg.* 23 ppm hourly avg.*
Nitrogen Dioxide	0.05 ppm (100 ug/m <sup>3</sup> ) annual arithmetic average	0.05 (100 ug/m <sup>3</sup> ) annual arithmetic average	100 ug/m <sup>3</sup> (0.05 ppm) 200 ug/m <sup>3</sup> (0.10 ppm) Max. annual arithmetic mean Max. 1-hr concentration not to be exceeded over 1 percent of the time in any 3-month period	0.10 ppm hourly avg.*
Photochemical Oxidants (Ozone)	0.12 ppm (235 ug/m <sup>3</sup> ) 1-hr average*	0.12 ppm (235 ug/m <sup>3</sup> ) 1-hr average*	235 ug/m <sup>3</sup> (0.12 ppm) Max. 1-hr concentration*	0.10 ppm hourly avg.*
Hydrocarbons (Less Methane)	24 ppm (160 ug/m <sup>3</sup> ) 3-hr concentration (6.9 a.m.)*	4 ppm (160 ug/m <sup>3</sup> ) Max. 3-hr concentration (6.9 a.m.)*	160 ug/m <sup>3</sup> (24 ppm) Max. 3-hr concentration (6.9 a.m.)*	None
Lead	1.5 ug/m <sup>3</sup> calendar quarter average	None	1.5 ug/m <sup>3</sup> quarterly arithmetic mean	1.5 ug/m <sup>3</sup> 90-day average
Foliar Fluoride	None	None	None	35 ug/g grazing season 50 ug/g monthly average
Visibility	None	None	0.4 coh. per 100 linear ft. Max. annual geom. mean (coefficient of haze)	Particle scattering coefficient of 3 x 10 <sup>-5</sup> per meter annual average***

\*Not to be exceeded more than once per year.

\*\*Not to be exceeded more than 18 times per any 12 consecutive months.

\*\*\*Applies only to PSD Class I areas.

Sources:

National Ambient Air Quality Standards 1978;

North Dakota Air Pollution Regulations 1978;

Montana Air Pollution Regulations 1980.



## APPENDIX D

### EMISSIONS OF RADIONUCLIDES IN PARTICULATE MATTER FROM A 1000 MW POWER PLANT: CONCENTRATION OF URANIUM, LEAD, AND POLONIUM IN FLY ASH ASSUMED (microcuries per day)

Coal Type	Bituminous	Bituminous	Subbituminous	Subbituminous	Bituminous
Radionuclide	Appalachia	Illinois- W. Kentucky	Powder River Basin Wyoming	Navajo Reservation New Mexico	Kaiparowits Plateau Utah
Uranium 238	66.5	150.0	63.5	87.5	48.0
Thorium 234	13.3	30.0	12.7	17.5	9.6
Protactinium 234	13.3	30.0	12.7	17.5	9.6
Uranium 234	66.5	150.0	63.5	87.5	48.0
Thorium 230	13.3	30.0	12.7	17.5	9.6
Radium 226	13.3	30.0	12.7	17.5	9.6
Radon 222	3,140.0	7,050.0	2,980.0	5,000.0	2,260.0
Polonium 218	66.5	150.0	63.5	87.5	48.0
Lead 214	66.5	150.0	63.5	87.5	48.0
Bismuth 214	13.3	30.0	12.7	17.5	9.6
Polonium 214	13.3	30.0	12.7	17.5	9.6
Lead 210	66.5	150.0	63.5	87.5	48.0
Bismuth 210	13.3	30.0	12.7	17.5	9.6
Polonium 210	66.5	150.0	63.5	87.5	48.0
Thorium 232	7.9	9.4	11.6	27.6	7.1
Radium 228	7.9	9.4	11.6	27.6	7.1
Actinium 228	7.9	9.4	11.6	27.6	7.1
Thorium 228	7.9	9.4	11.6	27.6	7.1
Radium 224	7.9	9.4	11.6	27.6	7.1
Radon 220	1,870.0	2,220.0	2,720.0	6,500.0	1,670.0
Polonium 216	7.9	9.4	11.6	27.6	7.1
Lead 212	39.5	47.0	58.0	138.0	35.5
Bismuth 212	7.9	9.4	11.6	27.6	7.1
Polonium 212	5.1	6.0	7.4	17.7	4.5
Thallium 208	2.8	3.4	4.2	9.9	2.6
Potassium 40	30.0	47.2	10.5	33.4	11.2
Total	5,635	10,550	6,331	12,610	4,389

Source: U.S. Environmental Protection Agency - Potential Radioactive Pollutants Resulting From Expanded Energy Programs (EPA-600/7-77-082) August 1977.

## APPENDIX E

### APPENDIX E-1 POLLUTANT EMISSIONS OF ALTERNATIVE 2

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Bloomfield	136.3	Gasification	579.6	72.5	352.8
South Wibaux-Beach	284.0	Gasification	200.5	48.5	138.6
Garrison	130.8	Electric power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0

TSP — Total suspended particulates

SO<sub>2</sub> — Sulfur dioxide

NO<sub>x</sub> — Nitrogen oxides (NO + NO<sub>2</sub>)

g/s — grams per second (1 g/s = 7.9 pounds per hour)

### APPENDIX E-2 POLLUTANT EMISSIONS OF ALTERNATIVE 3

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Burns Creek	174.2	Liquefaction	327.6	14.1	556.9
Central Bloomfield	77.2	Electric power	948.8	47.3	710.6
Circle West III	214.3	Liquefaction	327.6	14.1	556.9
South Wibaux-Beach	283.9	Gasification	200.5	48.5	138.6
Garrison	130.8	Electric power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0
Truax	117.7	Electric power	948.8	47.3	710.6
Werner	173.4	Electric power	948.8	47.3	710.6

### APPENDIX E-3 POLLUTANT EMISSIONS OF ALTERNATIVE 4

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Burns Creek	174.2	Liquefaction	327.6	14.1	556.9
Circle West III	214.3	Liquefaction	327.6	14.1	556.9
South Wibaux-Beach	283.9	Gasification	200.5	48.5	138.6
Garrison	130.8	Electric Power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0
Truax	117.7	Electric power	948.8	47.3	710.6
Werner	173.4	Electric power	948.8	47.3	710.6
Zenith	326.8	Gasification	579.6	47.3	352.8

## APPENDIX D

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Uranium 234	66.5	150.0	63.5	87.5	48.0
Thorium 230	13.3	30.0	12.7	17.5	9.6
Radium 226	13.3	30.0	12.7	17.5	9.6
Radon 222	3,140.0	7,050.0	2,980.0	5,000.0	2,260.0
Polonium 218	66.5	150.0	63.5	87.5	48.0
Lead 214	66.5	150.0	63.5	87.5	48.0
Bismuth 214	13.3	30.0	12.7	17.5	9.6
Polonium 214	13.3	30.0	12.7	17.5	9.6
Lead 210	66.5	150.0	63.5	87.5	48.0
Bismuth 210	13.3	30.0	12.7	17.5	9.6
Polonium 210	66.5	150.0	63.5	87.5	48.0
Thorium 232	7.9	9.4	11.6	27.6	7.1
Radium 228	7.9	9.4	11.6	27.6	7.1
Actinium 228	7.9	9.4	11.6	27.6	7.1
Thorium 228	7.9	9.4	11.6	27.6	7.1
Radium 224	7.9	9.4	11.6	27.6	7.1
Radon 220	1,870.0	2,220.0	2,720.0	6,500.0	1,670.0
Polonium 216	7.9	9.4	11.6	27.6	7.1
Lead 212	39.5	47.0	58.0	138.0	35.5
Bismuth 212	7.9	9.4	11.6	27.6	7.1
Polonium 212	5.1	6.0	7.4	17.7	4.5
Thallium 208	2.8	3.4	4.2	9.9	2.6
Potassium 40	30.0	47.2	10.5	33.4	11.2
Total	5,635	10,550	6,331	12,610	4,389

Source: U.S. Environmental Protection Agency - Potential Radioactive Pollutants Resulting From Expanded Energy Programs (EPA-600/7-77-082) August 1977.

## APPENDIX E

### APPENDIX E-1 POLLUTANT EMISSIONS OF ALTERNATIVE 2

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Bloomfield	136.3	Gasification	579.6	72.5	352.8
South Wibaux-Beach	284.0	Gasification	200.5	48.5	138.6
Garrison	130.8	Electric power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0

TSP — Total suspended particulates

SO<sub>2</sub> — Sulfur dioxide

NO<sub>x</sub> — Nitrogen oxides (NO + NO<sub>2</sub>)

g/s — grams per second (1 g/s = 7.9 pounds per hour)

### APPENDIX E-2 POLLUTANT EMISSIONS OF ALTERNATIVE 3

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Burns Creek	174.2	Liquefaction	327.6	14.1	556.9
Central Bloomfield	77.2	Electric power	948.8	47.3	710.6
Circle West III	214.3	Liquefaction	327.6	14.1	556.9
South Wibaux-Beach	283.9	Gasification	200.5	48.5	138.6
Garrison	130.8	Electric power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0
Truax	117.7	Electric power	948.8	47.3	710.6
Werner	173.4	Electric power	948.8	47.3	710.6

### APPENDIX E-3 POLLUTANT EMISSIONS OF ALTERNATIVE 4

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Burns Creek	174.2	Liquefaction	327.6	14.1	556.9
Circle West III	214.3	Liquefaction	327.6	14.1	556.9
South Wibaux-Beach	283.9	Gasification	200.5	48.5	138.6
Garrison	130.8	Electric Power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0
Truax	117.7	Electric power	948.8	47.3	710.6
Werner	173.4	Electric power	948.8	47.3	710.6
Zenith	326.8	Gasification	579.6	47.3	352.8

# **APPENDIX E-4** **POLLUTANT EMISSIONS OF ALTERNATIVE 5**

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Bloomfield	136.3	Gasification	579.6	72.5	352.8
Burns Creek	174.2	Liquefaction	327.6	14.1	556.9
Circle West III	214.3	Liquefaction	327.6	14.1	556.9
Redwater II	153.7	Electric power	948.8	47.3	710.6
South Wibaux-Beach	283.9	Gasification	200.5	48.5	138.6
Garrison	130.8	Electric power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0
Truax	117.7	Electric power	948.8	47.3	710.6
Werner	173.4	Electric power	948.8	47.3	710.6
Zenith	326.8	Gasification	579.6	47.3	352.8

# **APPENDIX E-5** **POLLUTANT EMISSIONS OF ALTERNATIVE 6**

Tract	Mining Emissions		End-Use Facility Emissions		
	TSP (g/s)	Type	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>x</sub> (g/s)
Bloomfield	136.3	Gasification	579.6	72.5	352.8
Burns Creek	174.2	Liquefaction	327.6	14.1	556.9
Circle West I	100.9	Electric power	948.8	47.3	710.6
Circle West II	99.8	Electric power	948.8	47.3	710.6
North Wibaux-Beach	322.1	Gasification	200.5	48.5	138.6
Redwater I	166.6	Gasification	579.6	47.3	352.8
Redwater II	153.7	Electric power	948.8	47.3	710.6
South Wibaux-Beach	283.9	Gasification	200.5	48.5	138.6
Southwest Glendive	178.2	Liquefaction	327.6	14.1	556.9
Garrison	130.8	Electric power	377.0	18.9	284.3
Sakakawea	13.2	—	0	0	0
Truax	117.7	Electric power	948.8	47.3	710.6
Werner	173.4	Electric power	948.8	47.3	710.6
Zenith	326.8	Gasification	579.6	47.3	352.8



# APPENDIX F

## EMISSIONS SOURCES FOR 1975 BASELINE

Name	Emission Rates			Emission Parameters			
	SO <sub>2</sub> (g/s)	TSP (g/s)	NO <sub>2</sub> (g/s)	Stack Height (m)	Diameter (m)	Temperature (°K)	Exit Velocity (m/s)
RM Heskett I	91.7	0.8	17.6	91.4	2.1	447.4	15.8
RM Heskett II	223.5	1.9	43.0	91.4	3.6	426.9	12.7
AMOCO Boiler 1	27.5	0.1	8.7	31.4	1.7	439.1	9.8
AMOCO Boiler 2	27.5	0.1	8.7	31.4	1.7	439.1	9.8
AMOCO Boiler 3	27.5	0.1	8.7	30.5	1.7	439.1	9.8
AMOCO CO Furnace	90.1	7.1	1.7	60.7	3.4	552.3	7.9
AMOCO Alk Furnace	20.2	0.0	5.3	53.3	1.9	444.0	8.0
Basin Leland Olds I	874.0	3.2	305.4	106.7	5.3	451.3	16.7
Basin Leland Olds II	1723.7	16.1	731.5	152.4	6.7	455.2	18.3
UPA Stanton	513.0	20.9	272.4	77.7	4.6	404.1	27.2
Milton R. Young I	575.6	2.6	383.8	91.4	5.8	449.7	21.3
Milton R. Young II	710.7	21.3	592.2	167.6	7.6	438.6	20.3
W.J. Neal I	25.4	1.0	40.7	42.4	1.8	478.0	25.6
W.J. Neal II	25.4	0.7	40.7	42.4	1.8	461.0	24.3
Montana SO <sub>2</sub> Flares I <sup>1</sup>	2421.5	0	0	0	0	0	0
Montana SO <sub>2</sub> Flares II <sup>1</sup>	3632.2	0	0	0	0	0	0
Montana-Dakota Utilities	131.0	191.4	65.3	61.0	2.1	474.7	43.6
Holly Sugar	0.45	29.2	0	78.0	3.2	493.0	10.0
N. Cheyenne Forest Prods	0	16.8	0	9.1	.8	589.0	5.87
Coal Creek Units 1 and 2	1598.0	132.0	931.4	201.0	6.7	404.0	27.2
Coyote ANG	673.0	56.1	492.7	152.0	6.4	374.0	27.4
Main 1 and 2	338.4	34.8	196.6	121.9	4.9	469.1	21.4
Start 1	60.0	0	8.0	48.8	3.2	1366.3	16.8
Start 2	13.6	0	1.0	48.8	3.2	1366.3	1.3
Antelope Valley Units 1 and 2	484.6	53.0	621.2	182.9	7.0	356.3	23.2
Warren Petroleum Claus Incin	81.7	0	0	59.4	1.8	810.9	5.2
Western Gas Claus Incin	28.4	0	0	30.5	0.46	866.3	19.8
Antelope Valley Unit 3	474.7	23.7	355.9	182.9	7.6	356.3	25.0
Nokota	327.6	14.1	556.9	152.4	11.2	394.0	12.2
St. Anthony Units 1 and 2	415.0	47.4	711.8	182.9	7.6	356.3	25.0
MP & L Units 1 and 2	892.1	44.6	892.1	213.4	10.5	340.8	12.6
Koch Hydrocarbon	26.0	0	0	45.7	0.6	894.1	12.7
Kerr McGee	55.3	0	0	61.0	0.2	1000.0	112.3
Perry Petrolane	7.9 <sup>2</sup>	0	0	54.9	0.1	1000.0	99.4
Shell Oil	44.8	0	0	61.0	0.2	1000.0	56.2
Phillips Petroleum	11.8	0	0	61.0	0.3	1273.0	20.0
AMOCO Claus Incinerator	31.4	0	0	45.7	1.1	810.8	12.2
Western Energy, Rosebud	1.86	194.1	31.8	0	0	0	0
Montana Power, Colstrip Units 1 and 2	188.3	31.7	500.5	152.4	5.03	366.3	32.0
Peabody Coal, Colstrip	0.6	39.3	0	0	0	0	0
Poplar River Power Plant, Coronach, Sask.	1352	56.7	454	122	7.1	425	14

Alternative 1 Mines

Antelope	0	105.6	0	0	0	0	0
Center	0	67.9	0	0	0	0	0
Glenharold	0	75.7	0	0	0	0	0
North Beulah	0	31.6	0	0	0	0	0
Renner	0	174.5	0	0	0	0	0
Schoolhouse	0	83.3	0	0	0	0	0
Underwood	0	143.8	0	0	0	0	0

<sup>1</sup>Estimated emissions from gas flares in Roosevelt County (I) and Richland County (II).

<sup>2</sup>According to NDS DH, this value has been revised to 25; however, the value shown was used in modeling studies by both the NDS DH and the present study.

## APPENDIX G

### DISPERSION MODELS AND PROCEDURES— BRIEF DESCRIPTION

MESOPUFF is a regional-scale, variable-trajectory Gaussian dispersion model. It simulates continuous plumes from multiple point and area sources by superimposing discrete Gaussian puffs advected by a changing wind field which accounts for regional dispersion meteorology. The model includes supporting modules for processing meteorological data, plume rise, plume chemistry for linear conversion of  $\text{SO}_2$  to  $\text{SO}_4$ , and pollutant removal through fallout (dry deposition) and removal by precipitation (wet deposition). MESOPUFF generates hourly and 24-hour average pollutant concentrations at each intersection of a two-dimensional modeling grid which covers the study area. The model also calculates 1-hour, 3-hour and 24-hour running averages at specified receptor points within the modeling grid.

CDMQC is a straight line Gaussian model which uses averaged statistical meteorology (STAR data) to calculate annual averages of  $\text{SO}_2$ , TSP and  $\text{NO}_2$ . CDMQC was designed for assessment of urban areas. The model was adapted for rural dispersion meteorology and for particle fallout in this study. The model was modified to also calculate concentrations over the modeling grid intersection points. Output was then processed to generate concentration isopleths.

CDMQC generates arithmetic averages; the TSP annual ambient standard, however, is a geometric mean (i.e., the Nth root of the product of a sequence of N values). The arithmetic algorithm in the model was therefore supplemented with one to calculate a geometric mean. To obtain meaningful results, the calculated concentration at each grid point for each meteorology must be added to the background concentration before being introduced into the algorithm. The modeled concentration plus background represents the simulation of a measured concentration. The calculated geometric mean is not linear with respect to the

background concentration used in the calculation; that is, the result can not be adjusted for a revised background level subsequent to the calculations.

Figure 3-1 shows the approximate extent of the area modeled. The same grid was used for modeling with MESOPUFF and CDMQC. The location of the origin of the grid was in the lower left-hand corner of the figure at approximately 340 kilometers (km) East, 5040 km North, in the Universal Transverse Mercator (UTM) coordinate system for Zone 13. The grid consisted of 55 by 43 grid cells with a resolution of 10 km on each dimension of a cell.

The preprocessor MESOPAC was used to process meteorological data, provided by NDSDH, into inputs for the MESOPUFF modeling. A grid consisting of 29 by 16 cells with a resolution of 30 km on each dimension of a cell was used. This grid had the same origin as the concentration grid, described above, with nine pollutant concentration cells per meteorological cell. Tables 2-9 and 2-10 of the technical report list the meteorological inputs for the three episodes which were modeled. Upper-air winds measured at the 950-millibar pressure level for all available rawinsonde stations such as Bismarck, Glasgow and Rapid City, were used to determine the transport of air contaminants.

Joint-frequency meteorological data for wind speed, wind direction and atmospheric stability were used in CDMQC modeling. These stability array (STAR) data were obtained from the National Climatic Center for Miles City in Montana, and Dickinson, Bismarck and Minot in North Dakota. Since CDMQC can only accommodate a single STAR data set, the STAR data for these four stations were averaged for use in this regional study. Other meteorological inputs required by CDMQC are mean afternoon and nocturnal mixing heights. Values of 1500 and 100 meters, respectively, were assigned.

# APPENDIX H

## PROJECTED POPULATION BY COUNTY AND ALTERNATIVE<sup>1</sup>

	Alternative					
	1	2	3	4	5	6
MONTANA						
Carter	2,083	2,083	2,083	2,083	2,083	2,083
Custer	16,026	15,931	15,941	15,931	15,967	15,945
Daniels	3,728	3,728	3,728	3,728	3,728	3,728
Dawson	12,610	13,790	15,366	14,307	17,542	20,435
Fallon	4,544	4,478	4,478	4,469	4,482	4,455
Garfield	1,669	1,756	1,734	1,782	1,778	1,753
McCone	3,053	3,124	3,106	3,118	3,144	7,516
Prairie	2,043	2,084	2,069	2,087	2,074	2,072
Richland	18,390	18,148	18,226	18,258	18,320	18,239
Roosevelt	12,179	12,513	12,618	12,630	12,681	12,591
Sheridan	8,387	8,387	8,387	8,387	8,387	8,387
Valley	10,708	10,708	10,701	10,694	10,698	10,702
Wibaux	1,161	1,923	1,901	1,902	1,910	5,057
NORTH DAKOTA						
Billings	1,214	1,216	1,216	1,220	1,220	1,220
Burleigh	74,160	74,158	74,157	74,157	74,157	74,157
Dunn	4,827	8,436	10,567	10,430	10,430	10,412
Golden Valley	2,980	7,284	7,278	7,327	7,327	5,564
McKenzie	7,759	7,761	7,784	7,783	7,783	7,782
McLean	13,788	14,272	14,382	14,382	14,382	14,379
Mercer	10,597	11,908	12,879	12,874	12,874	12,874
Morton	31,427	31,494	31,522	31,549	31,549	31,547
Oliver	2,743	2,745	2,747	2,747	2,747	2,747
Stark	27,422	27,627	27,672	32,202	32,202	32,145
Ward	70,209	70,481	70,692	70,690	70,690	70,687

<sup>1</sup>Projections for Montana counties are to the year 2000; those in North Dakota are for 1997.

# APPENDIX I

## ESTIMATED VEHICULAR EMISSIONS (pounds per day)

County	Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5			Alternative 6		
	CO	HC	NO <sub>x</sub>	CO	HC	NO <sub>x</sub>	CO	HC	NO <sub>x</sub>	CO	HC	NO <sub>x</sub>	CO	HC	NO <sub>x</sub>	CO	HC	NO <sub>x</sub>
<b>MONTANA</b>																		
Daniels	5,875	694	507	5,875	694	507	5,875	694	507	5,875	694	507	5,875	694	507	5,875	694	507
Dawson	19,872	2,349	1,716	21,733	2,568	1,877	24,216	2,862	2,091	22,547	2,665	1,947	27,646	3,267	2,388	32,205	3,806	2,781
McCone	4,812	569	416	4,923	582	425	4,895	579	423	4,914	581	424	4,955	586	428	11,845	1,400	1,023
Richland	28,982	3,425	2,503	28,501	3,380	2,470	28,723	3,395	2,481	28,774	3,401	2,485	28,872	3,412	2,494	28,743	3,397	2,482
Roosevelt	19,193	2,268	1,658	19,719	2,330	1,703	19,885	2,350	1,717	19,904	2,352	1,719	19,985	2,362	1,726	14,107	1,667	1,718
Sheridan	13,218	1,562	1,142	13,218	1,562	1,142	13,218	1,562	1,142	13,218	1,562	1,142	13,218	1,562	1,142	13,218	1,562	1,142
Wibaux	1,830	216	158	3,031	358	262	2,996	354	259	2,998	354	259	3,010	356	260	7,970	942	688
Carter	3,282	388	283	3,282	388	283	3,282	388	283	3,282	388	283	3,282	388	283	3,641	430	314
Custer	25,257	2,985	2,181	25,106	2,967	2,168	25,122	2,969	2,170	25,106	2,967	2,168	25,163	2,974	2,173	25,129	2,970	2,170
Fallon	7,161	846	618	7,057	834	609	7,057	834	609	7,043	832	608	7,064	835	610	7,021	830	606
Garfield	2,630	311	227	2,768	327	239	2,733	323	236	2,808	332	242	2,802	331	242	2,763	326	239
Prairie	3,220	381	278	3,285	388	284	3,261	385	282	3,289	389	284	3,269	386	282	3,265	386	282
Valley	16,876	1,994	1,457	16,876	1,994	1,457	16,864	1,993	1,456	16,863	1,992	1,456	16,860	1,993	1,456	18,195	1,993	1,457
<b>NORTH DAKOTA</b>																		
McKenzie	17,176	2,030	1,483	17,181	2,031	1,484	17,232	2,036	1,488	17,229	2,036	1,488	17,229	2,036	1,488	17,228	2,036	1,488
Ward	155,427	18,369	13,423	156,029	18,440	13,475	156,497	18,495	14,120	156,493	18,495	13,515	156,493	18,495	13,514	156,486	18,494	13,515
Burleigh	164,175	19,402	14,179	164,169	19,402	14,178	164,168	19,402	14,178	164,168	19,402	14,178	164,168	19,402	14,178	164,168	19,402	14,178
McLean	30,524	3,607	2,636	31,595	3,734	2,729	31,838	3,763	2,750	31,838	3,763	2,750	31,838	3,763	2,750	31,831	3,762	2,749
Mercer	23,460	2,773	2,026	26,362	3,116	2,277	28,511	3,369	2,462	28,500	3,368	2,461	28,500	3,368	2,461	28,500	3,368	2,461
Morton	69,572	8,222	6,008	69,721	8,240	6,021	69,783	8,247	6,027	69,843	8,254	6,032	69,843	8,254	6,032	69,838	8,254	6,031
Oliver	6,073	718	524	6,077	718	525	6,082	719	525	6,082	719	525	6,082	719	525	6,082	719	525
Billings	2,688	318	232	2,692	318	233	2,692	318	233	2,701	319	233	2,701	319	233	2,701	319	233
Dunn	10,686	1,263	923	18,671	2,207	1,613	23,394	2,765	2,020	23,089	2,729	1,994	23,089	2,729	1,994	23,049	2,724	1,991
Golden Valley	6,597	780	570	16,125	1,906	1,393	16,112	1,904	1,391	16,221	1,917	1,401	16,221	1,917	1,401	12,318	1,456	1,064
Stark	60,702	7,174	5,243	61,161	7,228	5,282	61,260	7,240	5,291	71,289	8,425	6,157	71,289	8,425	6,157	71,158	8,410	6,146



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# GLOSSARY

**AAGS.** Ambient air quality standard(s) (q.v.).

**ACID PRECIPITATION.** Rainfall and/or snowfall having a higher degree of acidity than that which occurs naturally (because of naturally occurring carbon dioxide in the atmosphere), or whose acidity is caused by acidic constituents other than carbon dioxide.

**AEROSOL.** A suspension of particles (solid or liquid) in the atmosphere.

**AIR BASIN.** A geographical region in which air quality phenomena are relatively uniform and appreciable different from those outside the basin.

**AIR QUALITY STANDARDS, PRIMARY.** National primary standards are meant to protect the health of most people with a margin of safety.

**AIR QUALITY STANDARDS, SECONDARY.** National secondary standards are meant to protect property and other human welfare values, such as aesthetics.

**ALBEDO.** The fraction of incident solar radiation which is reflected.

**AMBIENT AIR QUALITY STANDARDS.** The permissible level of various pollutants in the atmosphere, as contrasted with emission standards, the permissible level of pollutants emitted by a given source. For the federal government, these are known as National Ambient Air Quality Standards (NAAQS).

**ANNUAL ARITHMETIC MEAN.** An annual average of stated values.

**ANNUAL GEOMETRIC MEAN.** For a one year period, the  $n$ th root of the products of  $n$  values.

**ATMOSPHERIC DEPOSITION.** The processes by which pollutants in the atmosphere are deposited on the earth's surface. These are wet deposition (e.g., acid rainfall) and dry deposition (e.g., dustfall) processes.

**ATMOSPHERIC DISCOLORATION.** A change in the color of the sky due to the presence of a pollutant. An example is a reddish brown color due to the presence of nitrogen dioxide.

**ATMOSPHERIC STABILITY.** The tendency of the atmosphere to enhance or to suppress vertical motion within it. The former is an unstable condition, the latter is stable. Stability depends primarily on the change in atmospheric temperature with altitude.

**BACKGROUND (concentration).** The long-term average concentration of an air pollutant in a region at points distant from emission sources.

**BASELINE.** A reference base relative to which project impacts are compared and evaluated; as, for example, air pollutant concentrations existing (past, present, or future) in the absence of the project under consideration. In reference to the regulation of the prevention of significant deterioration (PSD) of air quality, baseline is

the existing level of a given pollutant for a given area to which the allowable PSD increment is added. The baseline usually is established when the first application for a PSD permit in the area is filed.

**CDMQC.** EPA guideline. Climatological Dispersion Air Quality Model.

**CONCENTRATION.** The relative content of a component (as dissolved or dispersed material) by weight or volume of material per unit weight or volume of the medium. As applied to air quality, the most commonly used units are micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), expressing weight per unit volume, and parts per million (ppm), volume per unit volume.

**CONCENTRATION, AVERAGE.** The average of a series of measurements of concentration.

**CST.** Central Standard Time.

**CUMULATIVE.** The total effect of separately determined but participating components.

**EMISSION.** Substances, usually unwanted, released by human activity into the environment.

**EMISSION INVENTORY.** A compilation of emissions and their rates from all sources, often designated by location.

**EPA.** Environmental Protection Agency (U.S.).

**FLY ASH.** Fine solid particles of noncombustible ash with or without accompanying combustible particles carried out of a bed of solid fuel by the draft and deposited in quiet spots within a furnace and flues or within a boiler setting, or carried out of a chimney with the waste gases and often recovered for use as a constituent in commercial products.

**GASEOUS PRECURSOR EMISSIONS.** Refers to air pollutants emitted into the atmosphere as gaseous compounds (e.g., sulfur dioxide) which subsequently may be converted to different pollutant species; gaseous, liquid or solid (e.g., sulfates from sulfur dioxide).

**GASIFIER ASH.** The inorganic residue after the incineration of coal in the gasification process.

**INCREMENT.** In reference to the regulation of the prevention of significant deterioration (PSD) of air quality, the increment is the maximum allowable increase in the level of pollution, over and above the existing baseline level. PSD increments are categorized as Class I, II, and III, according to the increasing magnitude of allowable concentrations.

**INTEGRAL VISTA.** A view from within a Class I area, extending outside the area's boundaries, which is important to the visitor's visual experience of the Class I area itself. Integral vistas associated with mandatory federal Class I areas are protected under the Clean Air Act.

**INVERSION.** An increase in air temperature with increasing height above the ground. This is a stable atmospheric condition.

**ION.** An atom or group of atoms which has gained or lost one or more electrons, and therefore has acquired an electric charge.

**ISOPLETH CONTOUR.** A line drawn on a map representing locations of equal value with respect to a particular parameter, such as concentration of an air pollutant.

**MESOPUFF.** Mesoscale Puff Gaussian dispersion model.

**MICROCURIE, uCi.** A unit of radioactivity intensity corresponding to  $3.7 \times 10^4$  nuclear transformations per second.

**MICROGRAMS PER CUBIC METER ( $\mu\text{g}/\text{m}^3$ ).** A unit of concentration; see "Concentration."

**MICROPHYSICAL.** Pertaining to physical processes or materials on a microscopic scale; for example, involving dust particles.

**MODELING GRID.** An area divided into square cells, in each of which a model calculates air pollutant or meteorological data.

**NDS DH.** North Dakota State Department of Health.

**NITRATES.** Compounds containing a subgroup of one nitrogen and three oxygen atoms; in atmospheres, a principal source is nitrogen oxides.

**NITRIC OXIDE ( $\text{NO}$ ).** A molecule of one nitrogen and one oxygen atom.

**NITROGEN DIOXIDE ( $\text{NO}_2$ ).** A molecule of one nitrogen and two oxygen atoms; results usually from oxidation of nitric oxide ( $\text{NO}$ ) in the atmosphere.

**NITROGEN OXIDES ( $\text{NO}_x$ ).** The mixture of oxidized nitrogen compounds found in exhaust emissions or in the ambient atmosphere and sometimes includes nitrates.

**$\text{NO}$ .** Nitric Oxide.

**$\text{NO}_x$ .** Nitrogen Oxides.

**$\text{NO}_2$ .** Nitrogen dioxide.

**PARTICULATE (matter).** Small particles, solid or liquid; when suspended in the atmosphere, they become an air pollutant; 15 microns or smaller in diameter; also called aerosol. Most particulate matter larger than 15 microns consists of silicate soil particles.

**PARTICULATE, CARBONACEOUS.** Particulate resulting from incomplete combustion of fuel, and therefore, containing carbon.

**PHOTOCHEMICAL OXIDANTS.** Strongly oxidizing chemical species, usually highly reactive and irritating

to sensitive organs, produced in the atmosphere from certain air pollutants under the influence of sunlight; includes ozone, nitrogen dioxide and others.

**PLUME.** The mixture of pollutants and air found downwind of a source of emissions. A plume may be visible or invisible.

**PREVENTION OF SIGNIFICANT DETERIORATION (PSD).** A regulatory program based not on the absolute levels of pollution allowable in the atmosphere but rather on the amount by which present air quality will be allowed to deteriorate in a given area.

**PSD.** Prevention of Significant Deterioration (q.v.).

**RADIOACTIVE TRANSFER.** The analysis of how visible energy is transferred from light to the observer; the processes include scattering and reemission of visible energy.

**RADIONUCLIDE.** A radioactive chemical element or isotope.

**RADON 220.** A radionuclide.

**RADON 222.** A radionuclide.

**RETROFIT.** In the air pollution control context, the application of air quality control technology to existing sources, as opposed to achieving air quality control through initial system design.

**$\text{SO}_2$ .** Sulfur dioxide.

**$\text{SO}_4$ .** Sulfate(s).

**STATE IMPLEMENTATION PLAN (SIP).** A state regulatory program, approved by the U.S. Environmental Protection Agency, under which the state is delegated full authority to regulate air quality on lands under its jurisdiction.

**SUB-BITUMINOUS.** A class of coal; intermediate in heating value between bituminous (higher) and lignite (lower).

**SULFATES ( $\text{SO}_4$ ).** Compounds containing a subgroup of one sulfur and four oxygen atoms; in the atmosphere, a principal source is sulfur dioxide.

**SULFUR DIOXIDE ( $\text{SO}_2$ ).** A molecule of one sulfur and two oxygen atoms; results usually from combustion of substances containing sulfur.

**TEMPERATURE INVERSION.** A meteorological phenomenon in which the temperature of the atmosphere increases with altitude, as opposed to the normal condition in which the temperature decreases at increasing altitude.

**THORIUM.** A radionuclide.

**TOTAL SUSPENDED PARTICULATES (TSP).** All particulate solid and liquid matter, except water, suspended in the atmosphere; includes dusts, smoke particles, pollen particles, and liquid or solid aerosols.

TRNP. Theodore Roosevelt National Park.

TSP. Total suspended particulates.

ug/m<sup>3</sup>. Micrograms per cubic meter.

URANIUM. A radionuclide.

VISIBILITY. A measure of: (1) the distance that objects can be seen (visual range), and (2) the contrast between an object and its surroundings. A reduction in visibility will reduce the distance that objects can be seen and will reduce the contrast between an object and the horizon.

VISUAL RANGE. See "Visibility."

VISUAL RANGE REDUCTION. An increase in general haze in the atmosphere.

WIND ROSE. A diagram showing the distribution of wind direction experienced at a given location. It most commonly consists of a circle from which 8 to 16 lines emanate, one for each compass point. The length of each line is proportional to the frequency of wind from that direction.



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